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# PLANTAGO CORDATA IN WISCONSIN

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## INTRODUCTION

Heartleaf plantain (*Plantago cordata* Lam.) is a large, semi-aquatic plant, which once was abundant throughout much of eastern United States. In 1969, Tessene published the first comprehensive study of the life history, reproductive biology, and distribution of *Plantago cordata.* He documented the disappearance of heartleaf plantain from streams altered or destroyed as a result of urban, industrial, and agricultural growth. Since that time, habitat elimination as well as stream erosion and siltation, channel scouring, and deteriorating water quality have resulted in continued decline of the plantain. As a result, *P. cordata* has been placed under consideration for listing as an endangered or threatened species by the U. S. Fish and Wildlife Service, with current status as a Category 2 Candidate for listing. *Plantago cordata* is also rare in Canada (Allen & Oldham 1985) and is protected under Ontario's Endangered Species Act.

Historically, *P. cordata* is known from six Wisconsin counties-Brown, Kenosha, Milwaukee, Outagamie, Pierce, and Racine (Tessene 1968; Read 1976; Alverson 1981). It is currently represented by one small population in southern Milwaukee County and a second population in Ozaukee Co. discovered in 1987. Land use changes threaten the quality of its habitat. Status in other states is equally grim, with the species considered endangered in several states (e.g., Alabama, Illinois, Indiana, North Carolina; Morgan 1980) and extirpated in Michigan (Wagner et al. 1977). Missouri and New York are the last strongholds for heartleaf plantain (Morgan 1980; Mitchell & Sheviak 1981).

Biological traits that may contribute to the vulnerability of heartleaf plantain include specific requirements for seedling establishment, short-term seed viability, and limited genetic variability (Tessene 1969). Primack (1980) discounts Tessene's claim of limited genetic variability and Meagher et al. (1978) demonstrate large ecological amplitude of adult plants, but do agree that seedling establishment is a critical phase of the life cycle. Meagher et al. (1978) provide an evolutionary explanation, suggesting that the plantain is strategically 'locked into' a life-cycle adapted to stable, meandering streams, rather than to high-gradient, shifting, unstable streams. It has low reproductive output compared to congeners (Primack 1979) and relies on low rates of adult mortality to persevere in its typical habitat of

meandering perennial streams with a limestone substrate or gently sloping unvegetated streambanks.

In April 1981, we initiated a study of the Wisconsin population of *P. cordata*. Our objectives were to quantify reproductive output, monitor seedling survival relative to microsite, experimentally determine optimal establishment conditions, document long-term adult survival rates, and describe the remaining habitat of the plantain.

## METHODS

*Study site.*

*Plantago cordata* grows in a narrow mud-bottomed tributary of the Root River, in a small (14 ha) woodlot owned by the Milwaukee County Parks Administration (Fig. 1). The woodlot has decreased little in acreage since 1937, based on analysis of aerial photographs taken at intervals from 1937 to 1980, but has undergone some selective woodcutting (Kunowski 1983). Land use in the section of land supporting the plantain was fairly constant from 1937 to 1974, with about 75% of the land under cultivation. In recent years, some farmland has been converted to industrial uses; two large industrial facilities were built upstream of the plantain population in 1975 and 1981. Currently, about 69% of the section is cultivated, 17% is in woodlots, and the remainder is industrial or residential.

Dominant trees in the woodlot surrounding the *P. cordata* population are sugar maple (*Acer saccharum* Marshall) and basswood (*Tilia americana* L.), with ironwood (*Ostrya virginiana* (Miller) K. Koch) in the understory, based on sampling of 40 points in the woodlot with the point-centered quarter method (Mueller-Dombois & Ellenberg 1974). Water-plantain (*Alisma subcordatum* Raf.), skunk cabbage (*Symplocarpus foetidus* (L.) Salisb.), and *Ranunculus septentrionalis* Poiret grow with *P. cordata* on the periodically inundated stream banks. The woodlot harbors several other rare species including *Hydrastis canadensis* L., *Trillium recurvatum* Beck, *Samolus floribundus* H.B.K., and *Viburnum prunifolium* L.. The flora consists primarily of species native to southern mesic forests (Curtis 1959) and does not support disturbance species such as *Lonicera* sp. and *Typha* sp. common in nearby areas. For a complete floral list see Stromberg et al. (1982). Species names follow Gleason and Cronquist (1963).

The plantain population occurs in the shade. Incident light on *Plantago* individuals (on June 2, noon) after canopy leaf-out ranged from 50 to 1000 f.c., when 10,000 f.c. was measured in adjacent unshaded areas.

Soil samples from the stream bank near the plantains are alkaline, with a high calcium content (nutrient analysis performed by the Wisconsin Soil and Plant Analysis Lab) (Table 1). Stream water is also very alkaline, and contained low levels of suspended solids during most of the growing season (stream water was sampled monthly from August 1981 to August 1982, using methods outlined in American Public Health Association et al. (1971), and United States Geological Survey (1977)). Water temperature and stream velocity showed much monthly fluctuation (Table 2).

Water upstream of the plantain population near the effluent release point of an industrial resin plant and at the confluence of the effluent and stream is noticeably less alkaline and warmer in winter compared to water at the plantain site. The effluent also contains substantially more seston (minute suspended organic material, including living and nonliving fractions) than stream water at the plantain site (Table 2). Effluent is filtered through a reed canary grass (*Phalaris arundinacea* L.) marsh before reaching the plantain population. Additional data on water quality are available upon request (Stromberg et al. 1982).

The stream water at the plantain site is polluted, according to a pollution index based on invertebrate species composition (Hilsenhoff 1977). The invertebrate samples contained many isopods (*Asellus intermedius*) and chironomids, resulting in a stream Biotic Index greater than 2.76 on all sampling dates, indicating organic pollution (Hilsenhoff 1977). The Biotic Index for a nearby site in the turbid Root River was also greater than 2.76 (Southeastern Wisconsin Regional Planning Commission 1980).

TABLE 1. Organic matter, pH, and nutrient content of streambank soil at the Root River *Plantago cordata* site.

| | pH | ORGANIC MATTER(%) | TOTAL N(%) | P | K | Ca | Mg | B | Mn | Zn | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | g/m2 | | | | | | | |
| Mean[1] | 7.7 | 8.9 | 0.14 | 8 | 13 | 443 | 97 | 0.3 | 97 | 2.3 | 6.0 |
| Std. dev. | 0.1 | 4.9 | 0.05 | 1 | 3 | 51 | 27 | 0.1 | 27 | 0.7 | 3.4 |

[1]n = 3

TABLE 2. Stream water characteristics of the Root River *Plantago cordata* site.

| DATE | | TOTAL ALKALINITY ($mg\ CaCo_3/L$) | DISSOLVED OXYGEN (mg DO/L) | TOTAL SUSPENDED SOLIDS (mg/L) | STREAM VELOCITY (ft/s) | WATER TEMP. (°C) | SESTON (mg/L) |
|---|---|---|---|---|---|---|---|
| 1981 | SEPT | 317 | 3.2 | 1.5 | 0.05 | 14.0 | 1.5 |
| | NOV | 303 | 9.7 | 5.7 | NA | 0.5 | 5.7 |
| 1982 | JAN | 304 | 0.2 | 12.3 | 0.05 | 0.5 | 12.3 |
| | MAR | 235 | 6.0 | 2.1 | 0.35 | 6.0 | 2.1 |
| | MAY | 296 | 5.2 | 1.0 | 0.45 | 13.0 | 1.0 |
| | JULY | 341 | 3.1 | 1.9 | 0.15 | 19.5 | 1.9 |

*Study population.*

Mature heart-leaf plantains are large plants (up to 1 m tall), which consist of from one to about 10 rosettes (growing points). Each distinct plant at the study site was considered a genet (a genetically distinct plant), and rosettes within plants were considered ramets (asexual off-shoots). Three life classes of plants were recognized: mature (plants with mean July leaf blade lengths longer than 15 cm, and one to many rosettes), juveniles (plants with blades shorter than 15 cm, one rosette, and older than one year), and seedlings (one rosette, less than one year old). Age of mature plants was not determined. Counts of alternating summer and winter leaf scars has been suggested for use in age determination (Tessene 1969), but such a method could endanger plant survival.

Locations of all *P. cordata* genets were mapped in spring of 1981. Plant deaths and new rosette production were scored monthly through September 1982. Inflorescences produced by the population were counted in 1981 and 1982. Number of seeds per capsule (n = 100), capsules per inflorescence (n = 15), and seed weight (n = 3 groups of 50 seeds) were measured on harvested random samples each year. Total leaf area per ramet (determined from leaf tracings) was measured on a sample of mature individuals both years. The population was revisited in 1986 and 1987, and surviving plants and new seedlings were counted.

Visits were made every other week in 1981 and 1982 to document seed germination and seedling survival. At all microsites where seedlings were observed, germination date and seedling number and size (leaf length and plant height) were recorded. Seedling locations were marked with toothpicks color- coded for germination date. Searches for seedlings encompassed an area from the parent population to 150 m downstream.

*Greenhouse experiments.*

Greenhouse experiments on germination and growth response to environmental conditions were conducted using seeds harvested at the study site. We determined percentage germination (n = 20 seeds; two replicates) in environmental chambers at three temperature regimes: 28/18, 21/12, and 12/7°C (values indicate daytime/nighttime temperatures); three light regimes: darkness, simulated sunlight and light filtered through basswood (*Tilia americana*) leaves; and at 5 water potentials by using polyethylene glycol as osmoticum: 0.05, -0.1, -0.2, -0.4 and -0.8 MPa. These germination tests were run at 28°C for 12 hours alternated with 12 hours at 18°C in full light, and on filter paper unless otherwise indicated. Germination was also determined on seven substrates, including three collected from the study site (clay soil, water, and branches

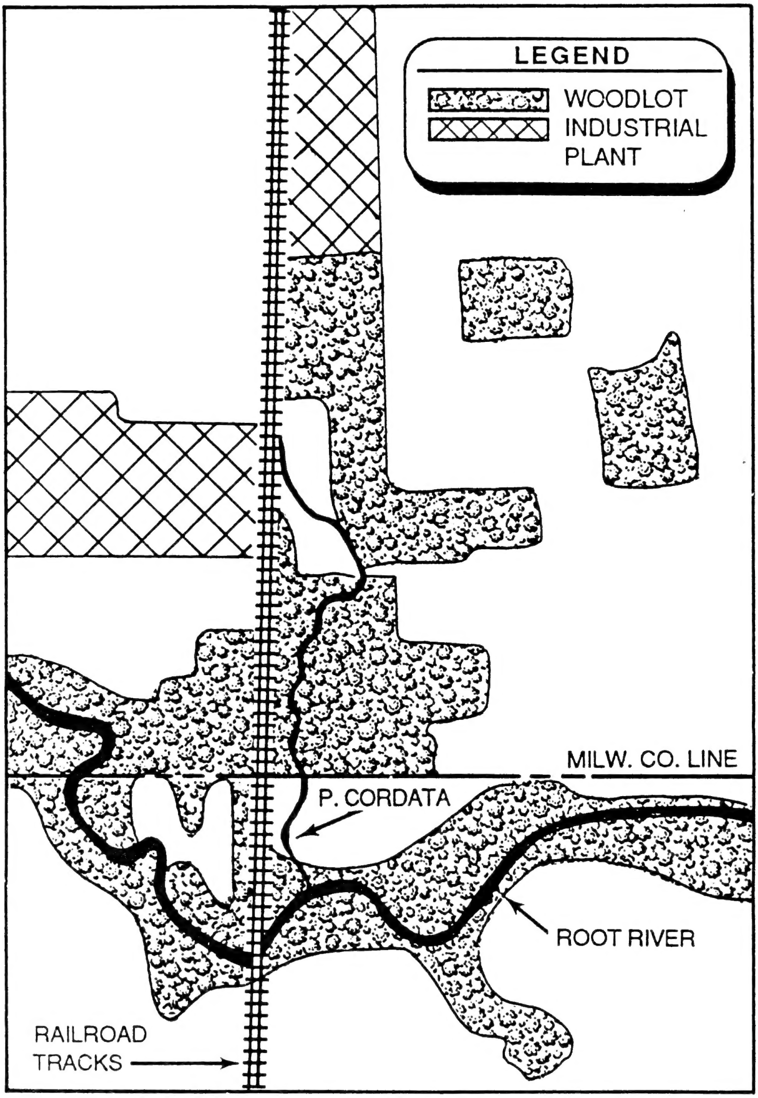


FIGURE 1. Map showing the location of Plantago cordata along the Root River tributary in Milwaukee County, and land uses in the square mile section containing the population and in the upper half of the section immediately to the south. Industrial plants are marked by cross-hatching, and woodlots by circles. Most of the unmarked land is under cultivation.

covered with moss (*Amblystegium riparium* (Hedwig) BSG)) and four commercial substrates (sand, loam, perlite, and peat-perlite mix). Survival and leaf growth (number and length) of seedlings on the substrates were recorded weekly.

Longevity was tested for seeds collected in 1981. Longevity was tested by storing freshly harvested seeds in two conditions: cold (5°C)/moist (= stratified) and room temperature/air-dried. Twenty seeds were removed from storage weekly initially, and then monthly, for germination testing.

## RESULTS: NATURAL POPULATION

*Population stability.*

Eleven plants were present when the *P. cordata* population was discovered in 1979. The population remained fairly stable during the study, with little adult mortality but considerable fluctuation of numbers of juveniles and seedlings. In 1981, 9 adult plants, one juvenile, and one seedling were counted at the site (Table 3 and Fig. 2); however, the juvenile died in the winter of 1981/1982. The juvenile (presumed to be the sole seedling survivor from 1980) was growing on a mossy log traversing the stream, a poor microsite for survival (see Seedling establishment). No adults died between 1981 and 1986. The population in 1986 consisted of the same nine adults present in 1981, one additional adult, three juveniles, and eight seedlings. Ten adults were also present in 1987; however, one of the original 1981 adult plants had died and another appeared senescent, consisting only of one small rosette. Both plants were in very dense shade while vigorous survivors were in a light gap, suggesting that reduced light may be a contributing cause of death.

*Reproduction.*

Heartleaf plantain reproduces vegetatively and sexually. Vegetative reproduction involves production of rosettes (ramets) from axillary buds on the caudex. In 1981, each mature plant had approximately four rosettes (Table 3). Eight of the nine mature plants produced one or two new rosettes in spring 1982, increasing average rosettes per plant to about six and bringing the total rosette number on mature plants from 39 to 52. Rosette density did not continue to increase over time, and by 1987, rosette densities had declined to about five per plant.

Anthesis occurred from mid-April to mid-May. Flowers are bisporangiate and produced on elongated inflorescences (spikes) (Mesler 1977). Spikes per genet ranged from a low of one per plant to 15, reflecting differences among plants in ramet density. Numbers of spikes per ramet were similar in 1981 and 1982, averaging a little over 2 per ramet. Spike number per genet plant was about 25% lower in 1981 than in 1982 (Table 4), perhaps reflecting the lower ramet density or greater spike mortality; several young spikes suffered frost damage in early and mid-April of 1981 and did not mature.

Although total spike number was higher in 1982, seeds per capsule declined by about 25%, resulting in somewhat lower (13%) seed production in 1982 (Table 4). However, abundant seeds (about 15,000) were produced

TABLE 3. Population size and structure for *Plantago cordata* at a site in Milwaukee County in fall of 1981, 82, 86 and 87.

| | 1981 | 1982 | 1986 | 1987 |
|---|---|---|---|---|
| TOTAL GENETS | 13 | 15 | 21 | 18 |
| Mature plants | 9 | 9 | 10 | 10 |
| Juvenile plants | 1 | 3 | 3 | 8 |
| Seedlings | 3 | 3 | 8 | 0 |
| TOTAL RAMETS | 43 | 58 | NA[1] | 55 |
| Mature plants | 39 | 52 | NA | 47 |
| Juvenile plants | 1 | 3 | NA | 8 |
| Seedlings | 3 | 3 | NA | 0 |
| RAMETS PER MATURE GENET: Mean and s.d. | 4.3(2.0) | 5.8(1.9) | NA | 4.7(2.8) |

[1] NA = not available.

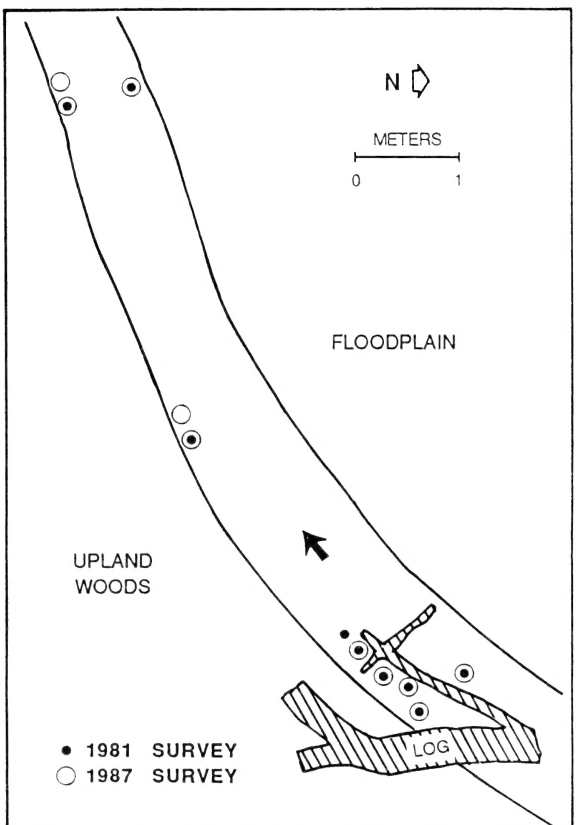


FIGURE 2. Locations of mature Plantago cordata plants along the Root River tributary in 1981 and 1987.

TABLE 4. Reproductive success of *Plantago cordata* at the Root River site in 1981 and 1982. Values listed are means followed by standard deviation.

| | 1981 | 1982 |
|---|---|---|
| INFLORESCENCE PRODUCTION | | |
| Number per ramet | 2.4 (1.1) | 2.2 (0.8) |
| Number per genet | 7.3 (3.9) | 9.1 (4.8) |
| Total number | 66 | 82 |
| SEED PRODUCTION | | |
| Capsules per spike | 86 (33) | 79 (22) |
| Seeds per capsule | 2.9 (0.9) | 2.2 (0.7) |
| Weight per seed (mg) | 1.8 (0.1) | 1.9 (0.1) |
| Total number | 16,460 | 14,252 |
| REPRODUCTIVE EFFORT | | |
| (seed weight in mg per 10 $cm^2$ leaf area) | 4.7 | 4.6 |

both years. Reproductive effort, defined here as weight of seeds produced per area of leaf surface, did not substantially differ between the two years. Although more rosettes (and thus more leaves) were present in 1982, leaf area per rosette declined.

*Seedling establishment.*

As seeds mature, their increased weight causes the spike to bend. Seeds are then dispersed a short distance from the parent onto the streambank or into the water. Seed dispersal began in the first and second weeks of June. Seeds are hydrochorous and gelatinous, and will float as seeds or seedlings until making contact with stream debris or the streambank. Over 80% of the established seedlings were found within one meter of a parent plant in both years. However, seeds were observed as far as 50 m downstream from the parent population in 1981, and 80 m in 1982. Dispersal distance seems to be related to the abundance of stream algae and other debris impeding seed flow.

Seeds germinated during a relatively short period, from mid-June to mid-July. Percentage germination of the seed crop was very low (about 2%) in both years of the study (Table 5). Survival of seedlings was also low, and was influenced by microsite quality. Seedlings were found in four microsites, which differed greatly in quality (Table 5). Unvegetated, periodically inundated streambanks provided the best habitat for seedling survival, although not necessarily for germination. Many ungerminated seeds but only 29 seedlings (9% of the total) were observed in this microsite in 1981. Three of these streambank seedlings, all located in a small light gap, survived to 1982. The one-year old plants were large (possessing 10 cm long leaf blades in June, 1982, and 23 cm in September), but did not flower. More seeds (30%) germinated in this favorable microsite in 1982, perhaps because reduction in algal blooms allowed more seeds to float to the streambanks. Seedlings that were observed during the November, 1986 visit were located in this same microsite.

TABLE 5. Seedling establishment of *Plantago cordata* at the Root River site in 1981 and 1982. Seedling microsites are listed in order of decreasing quality for survivorship.

| | 1981 | 1982 |
|---|---|---|
| SEEDLINGS | 320 | 309 |
| SEED CROP GERMINATED (%) | 1.9 | 2.2 |
| SEEDLINGS OCCURRING ON: | | |
| Streambank, not under parents | 29 (9%) | 99 (32%) |
| Moss covered logs | 90 (28%) | 65 (21%) |
| Streambank, under parent plants | 48 (15%) | 93 (30%) |
| Algal mats | 154 (48%) | 53 (17%) |

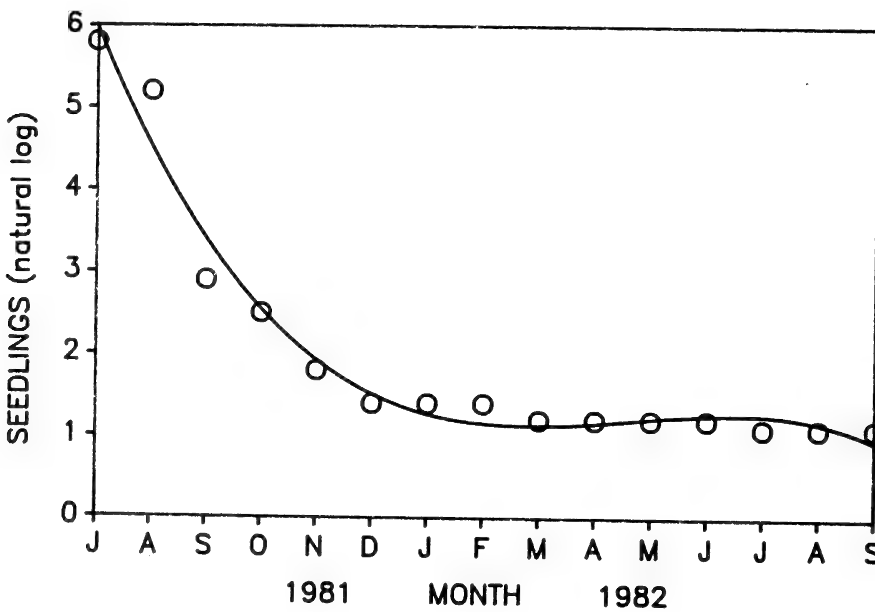


FIGURE 3. Survival of 1981 seedling cohorts of Plantago cordata at the Root River study site.

Many streambank seedlings in 1981 and 1982 germinated under parent *P. cordata* plants on leaf litter. In contrast to those not under the parent canopy, these showed high mortality and none survived to 1982.

About one-fourth of all seedlings in both years were on moss-covered fallen logs and branches in the stream channel. The dominant moss, *Amblystegium riparium,* is a species that occurs in calcareous springs and swamps on wet humus, fallen branches, and leaf litter (Crum & Anderson 1981). Plantain seedlings on logs grew more slowly than those on soil substrates;

mean leaf blade length at 4 months (in October) was 2 cm compared to 7 cm for the streambank group. No seedlings on logs survived the winter.

In 1981, many seeds were trapped in algal colonies, the poorest microsite. The algal colonies formed dense mats in the water, and were composed primarily of *Rhizoclonium hieroglyphicum* (Ag.) Keitz and *Vaucheria woroniana* Heering. Many entrapped seeds germinated while floating or submerged, with the result that nearly half of the 320 seedlings present in 1981 occurred in algal colonies. None of these survived to 1982, although some remained alive for as long as five weeks, indicating the potential for long-distance dispersal as seedlings. Fewer seedlings were found in algal mats in 1982, perhaps because of an observed decrease in algal abundance.

Overall, only one percent (3 of 320) of the seedlings present in 1981 survived to 1982. Seedling survivorship followed a negative exponential curve (Fig. 3). Most deaths occurred in July and August, when seedlings were less than two months old. Mortality was caused by several factors, including prolonged submersion in algal mats, snagging and uprooting on raised branches, and/or herbivory. Large rainstorms occurred periodically, resulting in short-term rise in water level; most seedlings rooted in soil survived these periods of submergence, although some seedlings were uprooted and became snagged on flood debris after the water level subsided. Herbivores (chiefly aquatic snails: *Physa* sp. and *Triiodopsis multilineata* (Say)) completely defoliated and killed many seedlings. A polyphagous weevil (*Barypeithes pellucidus* (Boheman)) was occasionally present on adult plants, but was not observed on seedlings. White-tailed deer (*Odocoileus virginianus*) are abundant at the site, but did not appear to damage (trample and/or consume) any *P. cordata.*

## RESULTS: GREENHOUSE EXPERIMENTS

*Germination.*

*Plantago cordata* seed germinated over a wide range of conditions. Germination percentages were over 85% under all light conditions and on all substrates (Table 6). Some of the seeds placed in water sank below the surface, but most submersed seeds germinated.

Two factors that did decrease and delay germination were negative water potential (Fig. 4) and cool temperatures (Table 6). Seeds required virtually no water stress for optimal germination, with water potentials of negative 0.1MPa depressing germination by 25% and potentials of 0.4MPa totally preventing germination.

*Seedling growth.*

Substrate had a substantial influence on seedling size and survival. Of the natural substrates, seedlings attained largest size on the clay soil (Table 7). However, the greatest growth overall occurred on a commercial potting mix (perlite/peat). Seedlings were eventually transplanted to this potting mix for maintenance of a greenhouse/transplant population (Stromberg et al. in

TABLE 6. Germination of *Plantago cordata* in controlled substrate, temperature and light conditions. Conditions are 28/18°C, simulated sunlight, and filter paper unless otherwise indicated. Substrates marked by 'S' were collected at the Root River study site. Values shown are means of two replicates of twenty seeds, followed by standard deviation.

| | GERMINATION (%) | | GERMINATION (%) |
|---|---|---|---|
| SUBSTRATE | | TEMPERATURE REGIME (°C) | |
| Clay soil (S) | 98 (0) | 28/18 | 98 (2) |
| Moss-covered logs (S) | 85 (3) | 21/12 | 96 (2) |
| Water (S) | 95 (2) | 12/7 | 2 (2) |
| Peat/perlite mix | 96 (1) | LIGHT REGIME | |
| Loam soil | 99 (1) | Dark | 98 (1) |
| Sand soil | 93 (2) | Sunlight | 95 (4) |
| Perlite | 98 (2) | Canopy light | 98 (2) |

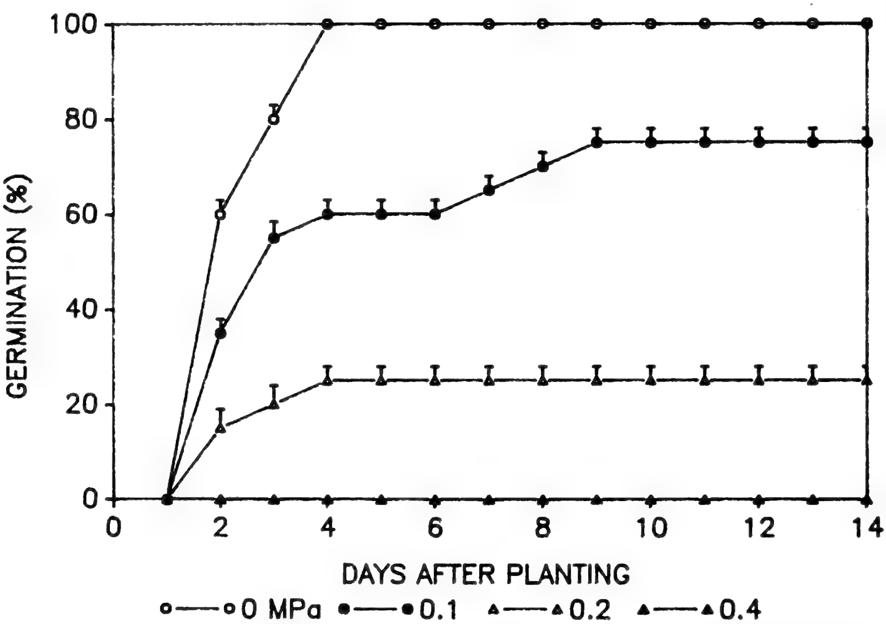


FIGURE 4. Cumulative germination of Plantago cordata in solutions with water potentials of 0, -0.1, -0.2, and -0.4 MPa. Data points are means of two replicates, with standard error bars.

prep.). Seedlings in water were 1/10 as large as those on soil substrates, and experienced high mortality. Aquatic seedlings remained alive for up to 5 weeks, similar to results observed for natural seedlings that had germinated while entrapped in algae.

TABLE 7. Growth of *Plantago cordata* seedlings in the greenhouse, as a function of substrate. Values shown are mean lengths of the first true leaf produced by seedlings (followed by standard deviation) at 1, 2, 3, and 4 weeks after germination. Sample size is 15 plants per substrate. Substrates marked by 'S' were collected at the Root River study site.

| | LEAF LENGTH (mm) | | | |
|---|---|---|---|---|
| SUBSTRATE | 1 week | 2 weeks | 3 weeks | 4 weeks |
| Peat/perlite | 0 0 | 4 4 | 28 7 | 36 13 |
| Loam soil | 0 0 | 3 3 | 20 10 | 31 8 |
| Clay soil (S) | 0 0 | 2 3 | 15 3 | 24 6 |
| Sand soil | 0 0 | 0 0 | 6 5 | 15 3 |
| Perlite | 0 0 | 0 0 | 6 4 | 8 3 |
| Moss-covered logs (S) | 0 0 | 0 0 | 6 3 | 8 3 |
| Water (S) | 0 0 | 0 0 | 2 1 | 3 1 |

*Longevity.*

Our results confirm rapid viability loss for dry-stored seeds (Tessene 1969; Meagher et al. 1978). Viability dropped to 20% after 1 month of dry room-temperature storage, and to 0% after 2 months. Seeds stratified in cool moist conditions had greater success; viability fluctuated between 100% and 70% for 5 months, declining to 40% at 14 months after storage, the last measurement date.

## DISCUSSION

The naturally occurring Root River *Plantago cordata* population is small, but evidently demographically stable. Contributing to this stability are the long life span of the plants (survival for five years was documented, and the large size of many plants at the beginning of the study suggests a much greater age), the low rates of adult mortality (contrasting with results for populations in other states, i.e., Meagher et al. 1978), and the low, but continual rates of annual seedling recruitment. That the population exists at all reflects the presence of the surrounding 'forest island' (Levenson 1981) and upstream marsh, which moderate water quality and filter sediment from agricultural and industrial processes, and buffer the population from excessive runoff, channel scouring and debris deposition (Schlosser & Karr 1981). However, the small size of the population may be a consequence of the fact that the stream habitat, particularly the water quality, has been impacted to some degree by human activities, as evidenced by the presence of invertebrate indicators of pollution. Lack of historical data precludes determination of the extent of change. In light of the small population size, further degradation in water quality resulting from continued industrial expansion represents a threat to the population.

Seedling establishment is the critical phase in the life- cycle of *P. cordata,* and is influenced by water quality and flow characteristics. Many seeds were deposited in unsuitable microhabitats, such as moss-covered logs or

dense growths of algae. Land use processes such as forest cutting that increase the intensity of flooding may have reduced habitat quality by increasing the abundance of logs and other stream debris. Low survival of transplants in high gradient streams confirms the species intolerance of such processes (Stromberg et al. in prep.). Eutrophication from agricultural run-off or increased temperature from industrial effluent may have increased algal growth, resulting in impeded dispersal and death of trapped seedlings.

Water quality may also impact seedling establishment through effects on herbivore predators. The abundance of herbivorous aquatic snails, which resulted in seedling death, may be a result of lowered water quality. The history of herbivory on Wisconsin *P. cordata* is unknown; however, Tessene in 1969 indicated that insect damage was rare. Decreased dissolved oxygen or increased silting may have eliminated or decreased abundance of 'biological controls' such as native fishes. One Brook Stickleback (*Culaea inconstans* (Kirtland)), a small fish of cold clean water (Scott & Crossman 1973), was found at the site in July 1982; larger fish populations in the past may have kept herbivore populations in check.

Reproductive output at Root River is equal to or higher than that recorded at other sites indicating that depressed seed production is not a cause of the small population. Inflorescence number per genet and reproductive effort are well above values reported by Meagher et al. (1978) and Primack (1979) for the species in North Carolina. Numbers of seeds per spike are within the range of 160 to 200 given by Tessene (1969) for his composite North American sample. However, Wisconsin plants may require more time to reach reproductive maturity (year-old plants in other states have been observed to flower) because of cooler conditions at the northern edge of the species range.

The influence of overstory canopy density on population success warrants further study. In addition to the mortality of mature plants in dense shade at the extant site, plants transplanted to dense shade at other locations in Wisconsin also have shown low growth and high mortality. In contrast, individuals in partial shade at these and other sites are vigorous (Stromberg et al. in prep.; Morgan 1980). Light gaps may be important areas of seedling establishment for heartleaf plantain, provided that sunlight does not cause soil drying and reduced germination, given the extreme sensitivity of *P. cordata* seeds to water stress, and provided that light does not increase densities of introduced or native ruderals, which may overgrow and outcompete the slower growing plantains (Stromberg et al. in prep.).

## SUMMARY

A remnant population of the endangered semi-aquatic plant *Plantago cordata* persists in a stream that meanders through a small 'forest island' in southern Wisconsin. The population is small but demographically stable because of low rates of adult mortality and low but continual seedling recruitment. A marsh upstream of the plantain population filters organic pollutants emitted from upstream industrial plants, but water quality has nonetheless undergone some deterioration. Deteriorated habitat conditions apparently are contributing to the small popula-

tion size by reducing the availability of suitable microsites for seedling establishment, a critical phase in the life-cycle of *P. cordata.*

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# QUANTITATIVE VARIATION IN OAK LEAF MORPHOLOGY WITHIN AND BETWEEN PIN OAK AND BLACK OAK

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Descriptions of leaf morphology are often qualitative, referring to aspects of general size and shape of both the lamina and lobes. Although experts can identify individual leaves, the extent of within-tree and between-tree variability is often such that identification is very difficult. In cases where leaf characters are used for discriminating closely related taxa, it may be necessary to conduct quantitative evaluations of leaf shape and size. This paper represents an example of such studies on two familiar but sometimes confused species — the pin oak, *Quercus palustris* Muenchh., and the black oak, *Q. velutina* Lam. Both species are common in the western Great Lakes region, each extending far to the east and south.

Leaf characters have long been recognized for their value in oak taxonomy (Rehder 1940; Fernald 1950; Gleason 1952; Chester et al. 1987), although there are varying opinions on their utility for specific purposes. For example, Muller (1942) noted that "the most valuable characters in *Quercus* . . . from subgenera to species are found in the leaves." However, not all leaf characters are thought to have taxonomic utility. Muller (1942) also expressed the opinion that "leaf size is too variable to be of critical value . . ." It is not clear if Muller (1942) was referring to overall leaf size or to any measure related to size. There are clearly cases in which leaf size can prove useful taxonomically. For example, while both *Q. imbricaria* Michx. and *Q. phellos* L. have simple, entire leaves, they can, in many instances, be differentiated easily by size differences (Fernald 1950; Chester et al. 1987). Jensen (1988) has shown that measures of leaf size can prove valuable for delimiting taxa in mixed species communities of oaks and for recognizing taxonomic groupings in polymorphic oak species complexes. Nevertheless, there are many instances in which, as Muller (1942) noted, size will prove to have little value for making taxonomic decisions.

In addition, the purposes for which leaf characters are being used will determine their utility. While measures of size will probably fail to differentiate *Q. rubra* L. and *Q. velutina* (both having rather large, lobed leaves) taxonomically, these same measures can be used to evaluate variation within and among populations of both species (e.g., Jensen et al. 1984).

Despite wide recognition of within-tree variation in oak leaf morphology (e.g., Wagner & Schoen 1976; Hicks & Burch 1977; Braham 1977), relatively little has been done to evaluate leaf variation within and among trees. One recommendation for conducting among-tree comparisons, standardization of collecting position, has been reaffirmed by several studies of

within-tree variation (Cousens 1963; De Rivas 1972; Olsson 1975; Baranski 1975; Braham 1977). From a comprehensive analysis of variation in leaf morphology within a number of trees, Blue and Jensen (1988) concluded that: (1) there is a significant amount of variation associated with season of collection (beyond simple increases in size); and (2) in agreement with Baranski (1975), height and branch position account for the greatest amount of detected variation. These results led to the recommendation that among-tree comparisons be based on leaves collected (1) at the same height and branch position on each tree and (2) either on the same date or after leaf growth has ceased. Blue and Jensen (1988) also concluded that standardizing collecting positions with respect to compass direction, e.g., always collect from the southern exposure, was unnecessary and impracticable. But, only two of the trees sampled by Blue and Jensen (1988) were completely open grown; in light of Braham's (1977) conclusion that leaves from the southern part of the crown are more reliable for comparative studies, the influence of compass direction on leaf morphology bears further assessment.

Blue and Jensen (1988) examined positional and seasonal effects on leaf morphology within individual trees of three species of oak: *Q. palustris, Q. rubra,* and *Q. velutina.* Although there were twelve trees included in their analyses, there was no attempt to conduct studies of variation among trees within a species, or of between-species variation. The study reported here is an extension of that of Blue and Jensen (1988) and differs in several important respects. First, while only two species (*Q. palustris* and *Q. velutina*) are examined, there are equal numbers of trees of each. Second, all trees are growing in proximity, simulating a "common garden" experiment. Trees studied by Blue and Jensen (1988) were from three distinct habitats, thus there was no control of environmentally induced variation. Third, this study examines components of variation among-trees within each species and between species. Fourth, we examine a variable designed to measure leaf symmetry. As noted by Wagner and Schoen (1976) and Hardin (1975) lack of leaf symmetry is often seen in trees of hybrid origin. To our knowledge, no other study of leaf variation in oaks has included an index of symmetry as one of the variables being analyzed. If such a measure is of value for assessing the status of putative hybrids, there must be reason to believe that it illustrates the same degree of within-tree, or within-species, constancy as other characters. Although the present study does not include any trees of putative hybrid status, it can serve as a base-line study for examining within-species variation in the proposed measure of symmetry.

Finally, in this study we evaluate the discriminatory power of the variables examined. That is, if each tree within a species, or if each species, has a unique set of morphological features, it should be possible to construct multiple linear discriminant functions which allow discrimination between the species and among the trees within each species.

The present study addresses several questions not answered by previous studies. First, do the variables studied illustrate significant levels of among-tree (within a species) and between-species variation. Second, is positional

variation the same in trees growing in proximity or are there signs of among-tree differences in positional variation. Third, do these morphological characters allow recognition of each tree within a species and each species as distinct multivariate entities. Fourth, does the proposed measure of leaf symmetry exhibit a pattern of among-tree variation which indicates its potential for identifying trees of putative hybrid origin.

## MATERIALS AND METHODS

The eight trees studied represent four black oaks (*Q. velutina*) and four pin oaks (*Q. palustris*) sampled on the campus of St. Mary's College, Notre Dame, Indiana during 1987. These trees are completely open grown and are located in the northeast section of the campus (distances between trees range from 9 to 130 meters and the total area encompassed is approximately 20000 $m^2$). Although the pin oaks sampled are planted trees, the source of all trees is known (the black oaks are naturally occurring trees while the pin oaks were transplanted from a natural woodlot in south-central St. Joseph County, Indiana). These trees ranged in height from 25–40 feet and in DBH from 23–57 cm. One or two terminal twigs were collected from the edge of the crown at eight locations on each tree. The eight locations were defined by the four cardinal compass directions and two heights (the lower edge of the crown and a point approximately 4/5 of the distance to the top of the tree). Leaves which were insect or frost damaged and obviously atypical were not sampled. All trees were sampled twice during the growing season, once in the spring (the first week of May) and again in early summer (the last week of May).

The sampling strategy yielded a total of 10–20 leaves per position per tree. These leaves were assigned numbers and a random number generator was used to select five leaves per position for recording data (giving a total of 40 leaves per tree). No attempt was made to control for leaf position on each twig. For each leaf, the number of bristle tips was recorded and the length of the petiole was measured. A digitizing pen was used to record thirteen pairs of X,Y coordinates for each leaf (Fig.1). The Y-axis was established as a line defined by points 0 and 7 (Fig.1), while the X-axis was defined as a line perpendicular to Y and passing through point 0. The digitized coordinates were used to calculate the measurements described in Table 1. The method for calculating angles was the same as that used by Blue and Jensen (1988). For example, using the three sides of triangle 7-0-4, the law of cosines was applied to determine ANG1R.

A measure of symmetry for each leaf was defined by calculating differences between the absolute values of X and Y coordinates for selected homologous points. Because the X,Y coordinate system for each leaf is determined in reference to points 0 and 7, if a leaf is perfectly symmetrical in size and shape then (1) the X coordinate of point 1 will be zero and (2) the absolute values of both X and Y coordinates for homologous points (e.g., 2, 12) will be identical. The equation defining the degree to which the actual values differ from those predicted is presented in Table 1 (for a perfectly symmetrical leaf, the index is 0; the upper bound of this index is not easily calculated, but is a function of the overall size of the leaf).

Each datafile was transferred to the Saint Mary's College PRIME 9955 computer. Factorial analysis of variance was conducted using the ANOVA routine in SPSS-X, version 2.1. A full factorial fixed effects model was employed. Because of evidence of departures from normality and of heteroscedasticity, all characters were log-transformed (base 10) prior to analysis (Sokal & Rohlf 1981). As noted by Blue and Jensen (1988), comparing leaves of different sizes is a confounding aspect of investigations such as these. Therefore, raw measurements were also transformed into size-corrected values by replacing each value by its residual derived from regression against a standard size variable, i.e., the square root of ((LBL + PTL) * LBWM). All characters were regressed against this size variable and the residuals were used as input for a second set of factorial ANOVAs. As noted by Reist (1985), differences in such residuals may be viewed as indicators of general shape differences.

Because our goal was to examine interspecific as well as intraspecific variation in each variable, each original measurement was included in four analyses. First, for examining interspecific variation the log and the residual values were used as input to a three-way fixed effects

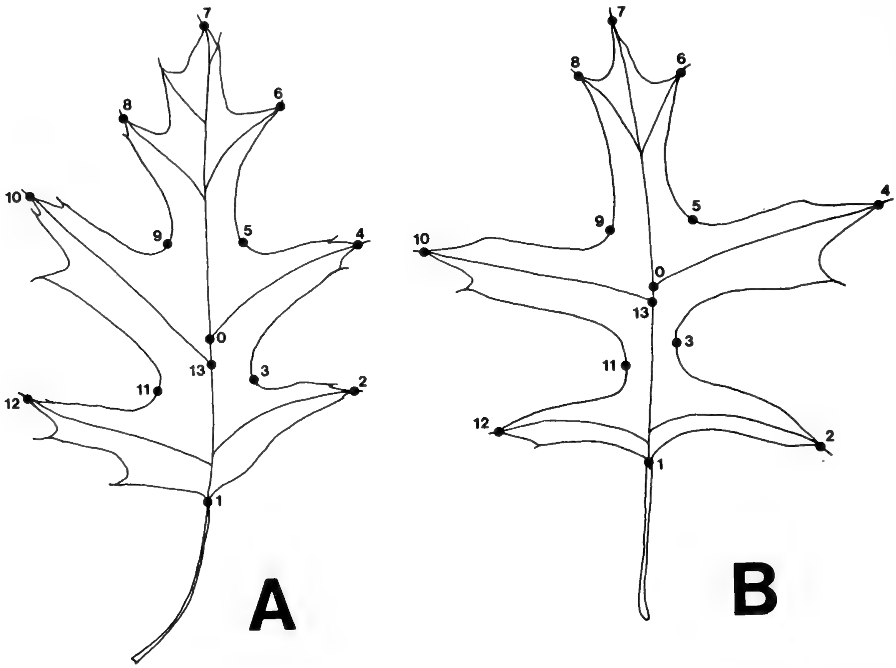


FIGURE 1. Tracings of black oak (A) and pin oak (B) leaves illustrating the 13 points digitized for X,Y coordinate data. Point labels correspond to character definitions in Table 1.

TABLE 1. Morphological characters evaluated[1]

| | |
|---|---|
| 1. NBT | = number of bristle tips |
| 2. PTL | = petiole length |
| 3. LBL | = leaf blade length (7–1) |
| 4. LBWB | = leaf blade width at base (2–12) |
| 5. LBWM | = leaf blade width at middle (4–10) |
| 6. LBWA | = leaf blade width at apex (6–8) |
| 7. SD | = sinus depth (4–5) |
| 8. OSW | = outer sinus width (4–6) |
| 9. INT | = intersinus width (3–11) |
| 10. ANG1R | = angle defined by (7–0–4) |
| 11. ANG1L | = angle defined by (7–13–10) |
| 12. ANG2R | = angle defined by (0–1–2) |
| 13. ANG2L | = angle defined by (13–1–12) |
| 14. SYM | = symmetry[2] |

[1] Numbers in parentheses refer to labeled points in Figure 1.
[2] The measure of symmetry was calculated using these equations:

XSYM = ABS(X(1)) + (ABS(X(2))-ABS(X(12))) + (ABS(X(3))-ABS(X(11))) + (ABS(X(4))-ABS(X(10))) + (ABS(X(5))-ABS(X(9))) + (ABS(X(6))-ABS(X(8)))

YSYM = (ABS(Y(2))-ABS(Y(12))) + (ABS(Y(3))-ABS(Y(11))) + (ABS(Y(4))-ABS(Y(10))) + (ABS(Y(5))-ABS(Y(9))) + (ABS(Y(6))-ABS(Y(8)))

SYM = XSYM + YSYM

factorial ANOVA with species, compass direction, and position (top, bottom) as the three levels of variation. Second, intraspecific variation was examined by splitting the data by species and then conducting a three-way fixed effects factorial ANOVA with tree, compass direction, and position as the levels of variation. Because Blue and Jensen (1988) found significant seasonal effects (including higher order interactions involving season as one factor) in both the log-transformed and the residual data, we analyzed the two sets of collections (season one and season two) separately to allow easier interpretation of within-and between-species variation. As Blue and Jensen (1988) noted, when so many tests have been conducted, the probability of a type 1 error can be reduced by reducing the level ($\alpha$) for accepting or rejecting the null hypothesis of equality of means. To yield an experiment-wise $\alpha$ of 0.05, taking into account four ANOVAs for each original measure, we have set $\alpha = 0.0125$ for evaluating the significance of each test (Harris, 1985).

In addition, we evaluated our proposed measure of symmetry by conducting tests of the hypothesis of equality of variances among-trees within each species. The ONEWAY routine in SPSS-X, version 2.1, was used to calculate both Cochrane's and the Bartlett-Box test of equality of variances. This test was performed on four sets of data: once for each species in each season.

Finally, we used these data for several multiple linear discriminant analyses. First we evaluated the utility of variables 1–13 (Table 1) for discriminating between pin oak and black oak. Second, we evaluated the utility of these same variables as discriminators among trees within each species. Our design consisted of two sets of discriminant analyses in each case: one for each form of the data (logs and residuals) and one for each season. Thus, we were able to assess whether the log or residual data gave better discrimination and whether data collected in the spring or early summer gave better discrimination. Discriminant analyses were performed using the DISCRIMINANT routine in SPSS-X, version 2.1. Each analysis was performed as a stepwise analysis using the default parameters with METHOD = MAHAL.

## RESULTS

### *Univariate Analyses*

*Interspecific Variation.* The pattern of variation seen for PTL (Table 2) was the same seen in most of the characters studied: significant species differences, for log and residual values, in both seasons. The only exceptions to this were OSW, for which there was no species difference in log values for season two, LBL, illustrating no species difference in season two, and LBWB (Table 2), which differed significantly between species only for log values in season two.

Compass direction yielded only one significant main effect (residual values for PTL in season one; Table 2), no significant two-way interactions, and a single significant three-way interaction in these analyses (in LBWB, Table 2).

On the other hand, almost every character revealed either significant main effects for position or significant two-way interactions involving position as one factor. An example of the general pattern is seen in Table 2, which presents the results for ANG1R (the other angles mimicked the results seen in Table 2). Some characters exhibited position effects only for the log (e.g., PTL, Table 2) or residual values, while NBT yielded no significant position effects. Finally, only two characters, PTL and LBWB (Table 2), had significant position by species interactions. Table 3 provides a view of the nature of these interactions. The significant species by position

TABLE 2. Interspecific variation in petiole length (PTL), leaf blade width at the base (LBWB) and angle ANG1R (as defined in Figure 1) detected by factorial ANOVA[1]

| | PTL | | | | LBWB | | | | ANG1R | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Season | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | |
| | L | R | L | R | L | R | L | R | L | R | L | R |
| Species (S) | * | * | * | * | | | * | | * | * | * | * |
| Compass (C) | | * | | | | | | | | | | |
| Position (P) | * | | * | | * | | * | | * | | * | * |
| S - C | | | | | | | | | | | | |
| S - P | * | * | | | | | | * | | | | |
| C - P | | | | | | | | | | | | |
| S - C - P | | | | | * | * | | | | | | |

[1] L = log values; R = residual values; * signifies the probability of equality of means is less than 0.05 (experiment-wise error; see text for discussion).

interactions for PTL occur in season one (Table 2). As seen in Table 3, all four pin oaks had greater values for PTL at the top than at the bottom whereas two of the black oaks, numbers three and four, had greater values at the bottom. There were no significant species by position interactions in season two, in which all trees illustrated the same pattern (higher values at the top).

*Intraspecific Variation.* Within each species, most characters illustrated significant among tree differences in log and residual values for both seasons (Table 4). Rarely was there a significant compass effect for any of the characters in either species. The exceptions were LBWM, SD, and ANG2L in pin oaks, each having a significant compass effect for residual values in season one, and INT in black oaks, which had a significant compass effect for log values in season one (Table 4). There were, however, a number of significant tree by compass interactions, as illustrated for INT in Tables 4 and 5 . For example, the highest and lowest values, respectively, of INT in season two for pin oak one were the south and west values. This relationship was reversed in pin oak two, and in pin oaks three and four the highest value occurred on the east (Table 5). Similarly, there was a significant tree by compass interaction for INT in the black oaks (Table 4); the mean values in Table 5 reveal that the highest value occurred at a different compass location in each tree for both seasons. Other characters having significant tree by compass interactions were LBWM and PTL in black oaks and SD and LBWA in pin oaks. In both species, characters which had no significant

TABLE 3. Means and standard deviations for PTL at Top and Bottom positions in each tree in each season

| | | Pin Oak | | Black Oak | |
|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 |
| T1[1] | Top | 3.56 ±0.66 | 3.50 ±0.76 | 3.78 ±1.47 | 5.69 ±1.54 |
| | Bottom | 2.62 ±0.68 | 2.83 ±0.57 | 3.64 ±1.02 | 4.37 ±0.98 |
| T2 | Top | 3.13 ±0.54 | 3.18 ±0.87 | 5.82 ±1.42 | 6.81 ±1.07 |
| | Bottom | 2.40 ±0.64 | 2.83 ±0.70 | 5.67 ±1.03 | 6.03 ±1.10 |
| T3 | Top | 3.32 ±0.88 | 3.85 ±0.82 | 4.22 ±0.77 | 5.08 ±1.01 |
| | Bottom | 3.08 ±0.62 | 2.95 ±0.66 | 4.53 ±0.96 | 4.70 ±0.95 |
| T4 | Top | 3.81 ±0.75 | 4.16 ±1.10 | 5.33 ±1.49 | 6.06 ±1.24 |
| | Bottom | 3.11 ±0.71 | 3.05 ±0.70 | 5.80 ±0.96 | 5.11 ±1.33 |

[1] T1, T2, etc. refer to individual trees of each species.

compass effects, and few or no interactions involving compass direction, were NBT (Table 4), LBWB, OSW, ANG1R, ANG2R, and ANG1L.

Significant positional effects were found for several characters within each species. As shown in Table 4, PTL illustrated significant positional effects for all analyses except that of season one log values in black oaks. Other characters illustrating significant positional effects were LBL, LBWM, LBWB, SD, OSW, and all angles. NBT did not yield significant main effects for position, but did have significant tree by position interactions for season one in black oaks (Tables 4, 6). As seen in Table 6, black oak one had its higher value at the top, black oak two had almost identical values at both positions, and black oaks three and four both had their higher value at the bottom. INT, OSW, and all angles also revealed significant tree by position interactions in black oaks. However, there were few such interactions in pin oaks. For example, INT (Table 4) had one significant main effect (residuals, season one) and no significant two-way interactions. This character, however, illustrated numerous significant three-way interactions.

*Multivariate Analyses*

The multiple linear discriminant analyses conducted with these data were designed to select those variables which would maximize discrimination: (1) between the species, and (2) among trees within each species. As can be seen in Tables 7 and 8, (1) the variables which maximize group discrimination

TABLE 4. Intraspecific variation in intersinus width (INT), number of bristle tips (NBT), and petiole length (PTL) detected by factorial ANOVA[1]

| | INT | | | | | | | | NBT | | | | | | | | PTL | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pin Oak | | | | Black Oak | | | | Pin Oak | | | | Black Oak | | | | Pin Oak | | | | Black Oak | | | |
| Season | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | | 1 | | 2 | |
| | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R |
| Tree (T) | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Compass (C) | | | | | * | | | | | | | | | | | | | * | | | | | | |
| Position (P) | | * | | | | | | | | | | | | | | | * | * | * | * | | * | * | * |
| T - C | | | * | * | * | * | | * | | * | | | | | | | | | | * | * | | * | * |
| T - P | | | | | | | * | * | | | | | * | * | | | | | | | | | | |
| C - P | | | | | | | | | | | | | | | | | | | | | | | | |
| T - C - P | | | * | * | * | * | * | * | | | | | * | * | * | * | | | | * | | | | |

[1] L = log values; R = residual values; * signifies probability of equality of means is less than 0.05 (experiment-wise error; see text for discussion).

differed between seasons one and two, (2) there was a tendency for log values to yield better discrimination than residual values, and (3) within a season, there was a different order of variable selection for logs and residuals but the same variables were included at the end.

Table 7 reveals that the two species could be discriminated slightly better in season one than in season two. In season one, there was no real basis for choosing between the log or residual values as species discriminators, the success of *a posteriori* classification being slightly higher for residuals, and only three variables (both basal angles and sinus depth) were not included in the final equation. However, in season two residual values were much less successful than were log values at *a posteriori* classification and there were fewer variables (only nine for logs, eight for residuals) included in the final equation.

Table 8 indicates that there were differences between these two species when attempts were made to discriminate among trees within each. First, regardless of whether log or residual values were used, the lists of variables in the final equation were identical in each analysis, but the variables chosen differed both between seasons and between species. In pin oak, only ten variables were chosen in season one while eleven were incorporated in season two. In black oak, twelve variables were selected in season one and all thirteen were selected in season two. Second, in pin oak the best *a posteriori*

TABLE 5. Means and standard deviations for intersinus width (INT) at the four compass directions in each tree in each season

| | | Pin Oak | | Black Oak | |
|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 |
| T1[1] | N[2] | 1.46 ±0.24 | 1.85 ±0.38 | 1.55 ±0.31 | 3.62 ±0.84 |
| | E | 1.57 ±0.37 | 1.86 ±0.31 | 1.59 ±0.43 | 3.91 ±0.48 |
| | S | 1.61 ±0.79 | 2.01 ±0.50 | 1.24 ±0.14 | 4.20 ±0.62 |
| | W | 1.39 ±0.22 | 1.49 ±0.27 | 1.89 ±0.48 | 3.54 ±0.71 |
| T2 | N | 1.77 ±0.56 | 1.64 ±0.45 | 2.04 ±0.29 | 2.83 ±0.86 |
| | E | 1.71 ±0.34 | 1.68 ±0.47 | 2.41 ±0.45 | 2.61 ±0.63 |
| | S | 1.56 ±0.43 | 1.35 ±0.31 | 2.55 ±0.52 | 3.29 ±0.91 |
| | W | 1.43 ±0.40 | 1.94 ±0.52 | 2.00 ±0.60 | 3.43 ±1.41 |
| T3 | N | 1.38 ±0.19 | 1.48 ±0.26 | 2.91 ±0.57 | 2.42 ±0.32 |
| | E | 1.74 ±0.75 | 1.55 ±0.22 | 2.14 ±0.42 | 3.23 ±0.91 |
| | S | 1.56 ±0.57 | 1.45 ±0.48 | 2.05 ±0.38 | 2.67 ±0.48 |
| | W | 1.62 ±0.59 | 1.45 ±0.41 | 2.51 ±0.46 | 2.79 ±0.34 |
| T4 | N | 1.49 ±0.53 | 1.40 ±0.20 | 1.86 ±0.48 | 3.85 ±0.55 |
| | E | 1.13 ±0.30 | 1.62 ±0.56 | 1.97 ±0.36 | 3.69 ±0.69 |
| | S | 1.19 ±0.20 | 1.47 ±0.25 | 1.40 ±0.35 | 3.59 ±0.64 |
| | W | 1.15 ±0.23 | 1.46 ±0.42 | 1.51 ±0.51 | 3.46 ±0.69 |

[1] T1, T2 etc., refer to individual trees of each species
[2] N, E, S, W refer to north, east, south, and west sides of the crown.

classification was achieved with residual values in season one but for black oak it was achieved with log values in season two.

*Analysis of Leaf Symmetry*

The proposed measure of leaf symmetry is clearly related to leaf size, its upper bound being a function of the maximal distances between homologous points. Thus, it is only logical that this measure will vary as a function of leaf size and must, therefore, be interpreted in reference to leaf size. With this in mind, only the residuals derived by regressing symmetry on leaf size were investigated.

Table 9 presents the results of conducting tests of equality of variances among-trees within-species in seasons one and two. From these results, we

TABLE 6. Means and standard deviations for number of bristle tips (NBT) at top and bottom positions in each tree in each season

| | | Pin Oak | | Black Oak | |
|---|---|---|---|---|---|
| | | Season 1 | Season 2 | Season 1 | Season 2 |
| T1[1] | Top | 24.0 ±4.1 | 22.7 ±5.3 | 17.2 ±3.7 | 16.0 ±4.6 |
| | Bottom | 22.5 ±5.2 | 22.2 ±2.5 | 15.3 ±3.9 | 15.0 ±3.9 |
| T2 | Top | 33.9 ±8.5 | 35.7 ±9.3 | 16.8 ±4.8 | 17.8 ±3.9 |
| | Bottom | 33.1 ±5.7 | 36.0 ±7.1 | 17.0 ±4.2 | 17.8 ±5.6 |
| T3 | Top | 20.9 ±4.0 | 22.9 ±3.3 | 23.2 ±5.9 | 24.2 ±4.3 |
| | Bottom | 21.2 ±3.2 | 21.5 ±3.3 | 27.3 ±5.3 | 26.2 ±5.8 |
| T4 | Top | 24.2 ±2.5 | 24.2 ±4.1 | 18.6 ±4.2 | 19.4 ±3.5 |
| | Bottom | 21.5 ±3.5 | 22.4 ±3.0 | 21.6 ±4.0 | 20.2 ±4.7 |

[1] T1, T2, etc., refer to individual trees of each species.

can conclude that the size-corrected measure of symmetry is equally variable among pin oaks in both seasons and among black oaks in season one. There was, however, significant inequality of variances among black oaks in season two.

## DISCUSSION

The questions posed in the introduction may be answered by examining the results presented herein. First, all variables examined illustrate significant differences both among-trees within each species and between species. These differences, however, are dependent on the season of collection. Second, there are significant positional effects for all variables, but there is a major difference between the results presented here and conclusions reached by Cousens (1962, 1963), Carlisle and Brown (1965), Olsson (1975), and Braham (1977). Third, the characters examined allow ready discrimination between species, although it is not as easy to discriminate among-trees within a species, and, fourth, our measure of symmetry illustrates rather uniform dispersion among trees within each species.

The most striking result from these studies is that, whether the comparisons are made between species or among-trees within a species, there is little evidence of marked differences in morphological variables as a result of compass direction. This result is in direct opposition to conclusions, which

TABLE 7. Order of variable selection and classification success for interspecific discriminant analyses

| | Season 1 | | Season 2 | |
|---|---|---|---|---|
| | Log | Residual | Log | Residual |
| | PTL | PTL | INT | INT |
| | LBWM | LBWA | LBWA | LBWA |
| | LBWA | LBWM | ANG1R | LBWM |
| | INT | INT | NBT | NBT |
| | NBT | NBT | ANG1L | PTL |
| | LBWB | LBWB | PTL | ANG1R |
| | ANG1R | LBL | LBWM | ANG1L |
| | ANG1L | ANG1R | LBL | OSW |
| | LBL | ANG1L | OSW | |
| | OSW | OSW | | |
| Classification Success | 99.4% | 99.7% | 99.1% | 85.0% |

TABLE 8. Order of variable selection and classification success for intraspecific discriminant analyses[1]

| | Pin Oak | | | | Black Oak | | | |
|---|---|---|---|---|---|---|---|---|
| | Season 1 | | Season 2 | | Season 1 | | Season 2 | |
| | L | R | L | R | L | R | L | R |
| | NBT | NBT | PTL | INT | LBWM | NBT | NBT | ANG2L |
| | ANG1L | INT | LBWM | ANG1R | PTL | PTL | ANG2R | PTL |
| | INT | ANG1L | ANG2R | ANG2R | NBT | ANG2R | LBWM | LBWM |
| | ANG2L | ANG2L | ANG1R | LBL | SD | INT | PTL | LBWA |
| | LBWB | LBWB | INT | LBWB | INT | LBWB | INT | NBT |
| | LBL | ANG2R | ANG1L | ANG2L | OSW | LBWM | LBWB | LBWB |
| | LBWM | LBL | LBWB | ANG1L | ANG2L | SD | OSW | INT |
| | ANG2R | ANG1R | ANG2L | PTL | ANG2R | ANG2L | ANG1R | LBL |
| | PTL | PTL | LBWA | LBWA | LBWB | LBL | LBWA | ANG1L |
| | ANG1R | LBWM | NBT | NBT | ANG1L | ANG1R | ANG2L | SD |
| | | | LBL | LBWM | LBL | ANG1L | ANG1L | ANG1R |
| | | | | | ANG1R | OSW | SD | OSW |
| | | | | | | | LBL | ANG2R |
| Success | 80.0% | 81.8% | 75.0% | 71.9% | 85.6% | 74.4% | 90.6% | 75.0% |

[1] L = log values; R = residual values

bear examination, made by other students of *Quercus*. Cousens (1962) observed that "Variation between different parts of the tree is so great that a specimen taken for diagnosis . . . should be selected . . . from accessible sun shoots on the South or South-East of the crown, . . ." Cousens (1963) reiterated this recommendation, yet in neither study were data or analyses, such as those presented herein, provided to support these observations. Carlisle and Brown (1965) concluded that among-tree comparisons should be based on leaves from the middle of shoots taken from the upper half of the south side of the crown. No data were provided to substantiate this

TABLE 9. Cochrane's C and Bartlett-Box F statistics from tests of the homogeneity of variances of SYM among trees within each species[1]

| Pin Oak | | | | Black Oak | | | |
|---|---|---|---|---|---|---|---|
| Season 1 | | Season 2 | | Season 1 | | Season 2 | |
| C | B | C | B | C | B | C | B |
| 0.29 | 0.85 | 0.29 | 0.58 | 0.27 | 0.30 | 0.38* | 4.28* |

[1] C = Cochrane's statistic; B = Bartlett-Box statistic; * = $p < 0.05$

claim; in fact, all results reported by Carlisle and Brown (1965) were based on the sampling strategy they concluded was best. Olsson (1975) also concluded that among-tree comparisons should be based on leaves collected from the same location on each tree: "To minimize variation . . . due to position on the tree, twigs were always taken from the south sides of the crown, . . ." Olsson's (1975) justification for this approach apparently was based on observations for a single character, the ratio of petiole length to total leaf length, recorded at the four compass directions from "an oak crown" of each of two species and a putative hybrid. These studies provided little evidence that compass direction has any significant effect on morphological characters.

Braham's (1977) results were more definitive in that he conducted tests for significant differences among leaves from different positions on a tree. Braham (1977) collected leaves from ten positions, five positions each on the north and south sides of three open grown white oaks, and pooled all collections (thus no among-tree differences could be detected). Univariate ANOVAs of thirteen characters revealed only two significant differences related to crown position. Braham (1977) also observed that "leaves collected at the periphery of the middle third of the crown, north side, generally had the largest character means . . . ," that under open-grown conditions leaves from the upper and lower crown may not be morphologically different, and that "In all but three characters . . . the south side of the crown was less variable than the north side." Braham (1977) concluded, as had Cousens (1962, 1963), Carlisle and Brown (1965), and Olsson (1975), that "Collections from open-grown trees to be used for comparative purposes are best collected from the south side, . . ."

The results presented here provide no support for the above claims that there are significant levels of variation associated with compass direction, whether the comparisons are made between species (Table 2) or among-trees within a species (Table 4). Further, these same results indicate that this lack of effect based on compass direction is constant across seasons. Despite differences in experimental designs, our results are consistent with those reported by Baranski (1975) and Blue and Jensen (1988).

As illustrated in Tables 3, 5, and 6, there is no evidence in our results that leaves from one location on a tree are consistently less variable than those

from any other location. In each table, the means and standard deviations are presented. If leaves from either position (top, bottom; Tables 3, 6) or any compass direction (Table 5) were consistently less variable, then the associated standard deviations should be smaller than those at other positions or directions. These three tables are typical of the results seen for all other variables: there is no apparent relationship between position or direction and variability.

The implication of these univariate results is that no general rule can be applied to sampling strategies. Attempts to evaluate the extent of morphological variability, either between species or among trees within a species, will contain components of variation which cannot be controlled. We have viewed this study as an approximation of a common garden experiment: all trees are growing in proximity. In general, when the test organisms are subject to the same growing conditions, observed differences can be postulated to have a strong genetic component. Thus, among-tree or between-species differences may be claimed to have a genetic origin. For large plants such as these, there are undoubtedly microenvironmental differences arising from a variety of factors, including, but not restricted to, (1) differential exposure to incident radiation and wind, (2) temperature differences as a function of differences in vertical and horizontal positions, and (3) resource competition among leaves on the same twig. While we have not attempted to account for the third, our sampling strategy did provide some control of the first and second.

The two-way and three-way interactions detected in our results are indicative of the nature of the problem. Not only must one account for variation among-trees, either within or between species, one is also faced with the fact that each tree does not provide a uniform response to the positional factors we have examined. Thus, a sampling strategy based on a rule such as that proposed by Cousens (1962) or Braham (1977) cannot provide control of positional effects. The only logical conclusion which can be drawn from these studies is that leaves should be collected from several positions on each tree and these collections pooled for evaluating among-tree variation.

A surprising (to us) result from these studies is that these two species are more easily discriminated in season one than in season two. A common rule of thumb for making comparisons between species has been to use mature leaves. If we consider the leaves collected in season two as mature leaves (all trees experienced leaf flushes within a two-three day period; Blue and Jensen (1988) found that most leaves have completed their growth by early June), then we are faced with the result that leaves collected in season one yielded consistently higher success rates for *a posteriori* classification following discriminant analysis. We do not, however, believe that this result should lead to the conclusion that immature leaves are best for species diagnosis. First, the differences in classification success, if residual values in season two are ignored, were negligible (differing by only 0.6 %). Second, these results indicate that, while size-corrected variables provided good separation in season one, these values were poor discriminators when the leaves were mature. This result stems from the difference these two species

exhibit with respect to petiole growth (Blue & Jensen, 1988): petiole growth in pin oaks occurs more rapidly, with respect to leaf blade growth, than in black oaks, thus there is a clear difference in season one. By season two, there is no longer this striking difference in the contribution of petioles to overall leaf size and the size-adjusted values perform more poorly (than do simple log-transformed values) as species discriminators. As indicated in Table 7, the two species may be discriminated quite readily by a subset of variables emphasizing aspects of leaf blade width, vein angles, and numbers of bristle tips.

Discrimination among-trees within each species is not nearly as good as discrimination between species (Table 8). The classification success rates do not illustrate the same pattern within each species. In pin oaks, there is little reason for preferring log values or residual values as discriminators. However, in black oaks, log values out-perform residual values in both seasons. In addition, maximal discrimination among pin oaks is achieved with fewer characters (10 or 11) than it is in black oaks (12 or 13). But, there is better discrimination among black oaks than among pin oaks. A general conclusion from these observations is that size-correction, as done here, provides no improvement in our ability to discriminate among trees within a species. In fact, the approach we have taken to size correction appears to provide no benefit for discriminating these two species, either (Table 7).

Our measure of symmetry shows promise for use in detecting the presence of hybrids. This conclusion is based on the fact that there were generally no differences in within-tree variability among trees within a species. The black oaks do illustrate significant differences in season two, demonstrating that within-tree variability is subject to seasonal changes associated with overall leaf growth. Nevertheless, if hybridization does lead to leaves with greater degrees of asymmetry than seen in leaves from trees which are not hybrids, then an analysis of among tree variation in symmetry might be expected to reveal that the putative hybrid is internally more variable than are trees representative of each probable parent.

A final observation about symmetry needs to be made. According to Braham (1977), "All leaves were assumed to be bilaterally symmetric" for data recording purposes. One of us (RJJ) has also made this assumption in past studies. Our results indicate that the assumption of bilateral symmetry cannot be justified. First, if the leaves were bilaterally symmetric, then the right and left angle measurements (ANG1R, ANG1L, ANG2R, ANG2L) would illustrate identical patterns of variation. While each angle has a pattern of variation similar to that seen in Table 2, each also illustrates a unique set of main effects and interactions. Second, our measure of symmetry is designed to produce a value of 0.0 in a leaf which is bilaterally symmetric. The raw values for symmetry illustrate a wide range of variation, ranging from a minimum value of 1.09 (in black oak one, season one) to a maximum value of 65.95 (in black oak four, season two). Further, the within-tree variances range from a low of 3.24 to a high of 82.63 (in the same two trees, respectively, as the minimum and maximum values). Although we may conclude that there is little evidence of among-tree differ-

ences with respect to the extent of variation in symmetry, it is clear that an assumption of bilaterally symmetric leaves is unwarranted.

## ACKNOWLEDGMENTS

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## REVIEW

CHECKLIST OF THE VASCULAR PLANTS OF ALGONQUIN PROVINCIAL PARK. Daniel F. Brunton. Algonquin Park Technical Bulletin No. 4. 1988. 32 pp. $1.00 CAN from The Friends of Algonquin Park, P.O. Box 248, Whitney, Ontario KOJ 2M0, CANADA.

Many readers will be familiar with and have fond memories of Algonquin Park in central Ontario. Now there is an up-to-date checklist of 993 taxa for reference while camping and canoeing. The list contains introductory material about the geology and ecology of the park, as well as explanations of symbols and nomenclature used in the list. While a checklist of a provincial park might seem of only local interest, the size of Algonquin Park, nearly 3,000 square miles, (well over half the size of Connecticut), makes the coverage of this list significant. Algonquin Park is also a fine, diverse place to botanize. The list contains 62 species of ferns and fern "allies," 34 species of orchids, and, for the connoisseur, 77 species of *Carex*. Great pains were also taken to make this list accurate, with all species on the list represented by specimens confirmed by authorities. How nice it would be if all parks had lists this accurate!

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## REVIEW

AMA HANDBOOK OF POISONOUS AND INJURIOUS PLANTS. By K.F. Lampe and M.A. McCann. Chicago Review Press. 1985. 432 pp. $18.95. (213 West Institute Place, Chicago, IL 60610).

This book claims to be a "reference source to management of plant intoxications and field guide for recognition of dangerous and injurious plants." As a medically-trained botanist, I can say the text is documented and referenced. The reader is told what part of the plant is toxic, the general class of toxin, symptoms, and some suggestions of medical management but he/she is wisely deferred to a detailed reference on the subject. As a plant identification manual, however, the books fails miserably. Many of the color photographs do not provide sufficient details to identify the plants they strive to illustrate. This book is no substitute for calling a professional botanist or mycologist onto the team for the identification of sometimes scanty plant materials.

—Barbara J. Dyko

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# BUR BUTTERCUP (CERATOCEPHALUS TESTICULATUS: RANUNCULACEAE): A POISONOUS WEED NEWLY ESTABLISHED IN OHIO.

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In 1977 I came upon a puzzling plant on South Bass Island in Lake Erie, Ottawa County, Ohio. The thick fruiting heads with spreading, separate carpels clearly indicated the Ranunculaceae. But using *Gray's Manual* and other standard references, I could not identify the species or even the genus. Ron Stuckey of Department of Botany, The Ohio State University came to my rescue. The mystery plant was *Ceratocephalus testiculatus* (Crantz) Roth, bur buttercup, a native of east-central and southeast Europe. Bur buttercup is listed as *Ranunculus testiculatus* Crantz in manuals where *Ceratocephalus* is not segregated from *Ranunculus*, such as McGregor et al. (1986). The treatment adopted here follows Tutin (1964) in *Flora Europaea.* In North America this species is a significant toxic weed of grazing lands in the western United States (Olsen et al. 1982). This is the first report of bur buttercup from east of the Mississippi River.

Since bur buttercup is not included in the standard regional manuals (Fernald 1950, Gleason & Cronquist 1963), a brief description is in order.

*Ceratocephalus testiculatus* is a scapose annual with flower stalks rising to 12 cm from a rosette of ternate to biternate leaves. The leaves are green and succulent when they first appear in the spring, but soon become cloaked with thin to dense gray hairs. The white to yellowish petals are quickly deciduous. The cylindric to subglobose fruiting head is the "bur" of the colloquial name. The carpel bodies are three-chambered. A central seed-bearing chamber terminated by a stiff, straight beak to 4 mm is flanked by two empty, pouch-like chambers; the derivation of the specific epithet *"testiculatus"* is obvious. As noted by Tutin (1964), the genus *Ceratocephalus* is separated from *Ranunculus* on the basis of this peculiar carpel body. As soon as the carpel bodies ripen, the leaves begin to wither. The Ohio population was in the peak of bloom on May 5, 1987. The plants had completely disappeared by the first of June.

Bur buttercup was first collected in North America in Utah in 1932 (Barkworth 1982). The species subsequently has been reported from British Columbia and 14 western states: Arizona, California, Colorado, Kansas, Idaho, Iowa, Montana, Nebraska, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming (Great Plains Flora Association 1977, McGregor et al. 1986, Pohl 1984, Rice et al. 1982, Scoggan 1978).

The Ohio population of *Ceratocephalus testiculatus* grows in the picnic

and camping areas of Erie Islands State Park on South Bass Island, Ottawa County. The plants were first observed 25 May 1977, *Cusick 16475* (KE, OS). The site was revisited 5 May 1987 and additional vouchers collected, *Cusick 26330* (CM, MICH, MU, NCU, NY, OS). The physical extent of the population had expanded considerably during this ten year interval. However, bur buttercup remains confined to the state park. This colony is the only one thus far known in Ohio. It has not been observed elsewhere on South Bass Island or in similar sites on nearby islands or the Ohio mainland. Appropriate habitats in the general vicinity include the state park campgrounds and/or picnic areas at Kelleys Island and Catawba Island State Parks, the latter a peninsula on the Ohio mainland.

The occurrence of *Ceratocephalus testiculatus* in Ohio has a significance beyond mere curiosity. Bur buttercup is an economically important poisonous weed in western rangelands. The species flourishes in barren, over-grazed habitats. The young plants are attractive to sheep in early spring, the green, succulent leaves conspicuous upon the trampled earth. Olsen et al. (1982) describes the deadly effect of bur buttercup poisoning on sheep. The lethal dose is as little as 1.1 pounds of green leaves to 100 pounds of body weight. I have not been able to determine if bur buttercup is poisonous to humans.

The Ohio habitat bears a considerable resemblance to the western rangelands. Here, too, the earth is nearly barren, trampled by the feet of literally thousands of park visitors. Attendance at this state park averages more than 250,000 people per year. Only a few other species survive in this harsh habitat. The most frequent associates of bur buttercup on South Bass Island are: *Cardamine hirsuta* L., *Lamium purpureum* L., *Myosotis stricta* Link, and *Poa bulbosa* L. These associated species likewise are non-indigenous to Ohio. This also is the first report of the two last-named species for the Erie Islands. The indigenous flora apparently is not able to withstand the severe impact of trampling on the thin, rocky soil.

It is uncertain exactly when *Ceratocephalus testiculatus* became established on South Bass Island. The species was not listed in earlier floristic surveys of the Lake Erie islands (Core 1948, Moseley 1899). The islands are well-botanized in summer when Stone Laboratory, the biological station of The Ohio State University, is in operation on nearby Gibraltar Island. Classes do not begin at Stone Lab until mid-June, however. By that time the bur buttercup seedheads have dispersed their fruits and the plant itself has disappeared. Botanists seldom visit the Erie islands in the spring.

One wonders how and from where bur buttercup was introduced to South Bass Island. The Iowa population also grows in a campground (Pohl 1984). This may only be a coincidence, but probably reflects the suitability of the species to trampled ground. Could the carpel bodies have come to Ohio riding in a backpack or in the mud on the chassis of a recreational vehicle?

Botanists in the Great Lakes region should be on the watch for *Ceratocephalus testiculatus*. Additional populations doubtless will be discovered of this new member of the weed flora of the Midwest.

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## EDITORIAL NOTICE: A NOTE OF THANKS

We would like to take this opportunity to express our thanks to Jim and Nancy Weber for the time and effort that they expended in editing *THE MICHIGAN BOTANIST* during the past several years. We deeply appreciate the guidance that they provided as we began our terms as Co-editors, assistance that made our assumption of their roles possible without a major interruption in the appearance of the journal. As we have so vividly seen during the course of the last several months, the task of editing a journal involves a number of "behind-the-issues" tasks that could become formidable if a well-organized system is not in place. Jim and Nancy provided not only a very workable scheme but also suggested how we might improve it. We are particularly grateful for the arrangements that they made when typesetting and printing operations were changed in 1987, establishing an excellent working relationship with a local firm that we will be continuing.

On behalf of the Michigan Botanical Club and our readers, thanks for all that you did for *THE MICHIGAN BOTANIST* and best wishes for your future endeavors in Oregon.

—Barbara J. Dyko
Richard K. Rabeler

## EDITORIAL NOTICE: LIST OF REVIEWERS

We wish to thank the following people who have reviewed articles for *The Michigan Botanist* during 1987 and 1988. Their comments were essential, helping our authors to prepare clear text and us in our position as editors. Their assistance is gratefully acknowledged.

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## NOTICE TO SUBSCRIBERS: THE NEXT INDEX

We have decided to return to producing an index covering three volumes of THE MICHIGAN BOTANIST. The next index will appear in Vol. 28, No. 4 and will cover Volumes 26–28.

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# NOTEWORTHY COLLECTIONS

## ONTARIO

GRIMMIA WRIGHTII (Sull.) Aust. (Grimmiaceae).

*Previous knowledge.* Crum and Anderson (1981) report this primarily North American moss species from western North America where it is found particularly on sandstone outcrops in prairie grasslands. It has been recorded from northern Mexico, Arizona, New Mexico, Texas, Colorado, Oklahoma, Kansas, Nebraska, Wisconsin, and Minnesota.

*Significance.* This collection appears to represent the only record of this species from eastern North America (R. R. Ireland pers. comm.) and the second report from Canada (Ireland et al. 1987), the first being from Alberta. The substrate upon which it was encountered may indicate that it is somewhat of a calciphile.

DISTRICT OF MUSKOKA: Six miles SW of Gravenhurst. One mile W of the junction of County Roads 13 and 19. In crevices of mortar on gatepost of Pioneer Cemetery on Kilworthy Road. One small colony. 22 Sep 1986, *Stewart 2373* (CANM). Specimen determined by Robert R. Ireland.

### LITERATURE CITED

Crum, H. A., & L. E. Anderson. 1981. Mosses of Eastern North America. Columbia University Press, New York. 2 vols. 1328 pp.

Ireland, R. R., G. R. Brassard, W. B. Schofield, & D. H. Vitt. 1987. Checklist of the mosses of Canada II. Lindbergia 13: 1–62.

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TORTULA NORVEGICA (Web.) Wahl. ex Lindb. (Pottiaceae).

*Previous knowledge.* This moss is reported by Crum and Anderson (1981) from northern and central Europe, the Caucasus, Himalayas, Siberia, and Japan. In North America it extends from southeastern Alaska and the Aleutians to California and inland to Alberta and Colorado. It also occurs disjunctively in Delta County in the Upper Peninsula of Michigan. It has also been reported casually from Manitoba and Ontario by Lawton (1971).

*Significance.* This record seems to represent the only collection from Ontario (R. R. Ireland pers. comm.).

DISTRICT OF MUSKOKA. Town of Gravenhurst. On soil in sun in Gravenhurst (Lakeview) Cemetery. Sparse. 22 Sep 1986, *Stewart 2379* (CANM). Specimen determined by Robert R. Ireland.

LITERATURE CITED

Crum, H. A., & L. E. Anderson. 1981. Mosses of Eastern North America. Columbia University Press, New York. 2 vols. 1328 pp.

Lawton, E. 1971. Moss Flora of the Pacific Northwest. Hattori Botanical Laboratory, Nichinan, Japan. 362 pp.

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## MICHIGAN

### SPHAGNUM OBTUSUM Warnst. (Sphagnaceae).

*Previous knowledge.* This species of rarity is known from widely scattered localities in the north from Greenland to Alaska and as far southward as southern Manitoba, northern Minnesota (Clearwater Co.), and western Ontario (Kenora District).

*Significance.* This is the first record for Michigan and the second known locality for the conterminous United States (Crum 1984, 1988).

*Diagnostic characters. Sphagnum obtusum* much resembles the *S. recurvum* complex, which is ubiquitous throughout the Boreal Forest, and it is, for that reason, easily overlooked in the field and the laboratory. The species is defined by microscopic characters, particularly those of the branch leaves. The hyaline cells lack the apical window pores of the *S. recurvum* complex, and on the outer surface they have only a few small end and corner pores or sometimes fairly numerous small, non-ringed, round pores or thin spots in addition to a fair number of ringed pseudopores and fibril connections. Toward the leaf base, especially on the outer surface, are many tiny thin spots in one or two rows over the cell surface or along the commissures. No useful information on habitat accompanies the only Michigan collection, but elsewhere the species seems to be limited to relatively mineral-rich sites, such as sedge mats and alder-dwarf birch fens.

**MICHIGAN.** Isle Royale, 1 mi. SW of Senter Point, 3 Aug 1937, *Millar Fleming s.n.* (in herb. Isle Royale National Park).

LITERATURE CITED

Crum, H. 1984. Sphagnopsida, Sphagnaceae. North Amer. Fl. 2, 11: 1–180.

______. 1988. A Focus on Peatlands and Peatmosses. Univ. of Michigan Press, Ann Arbor, 306 pp.

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# MICHIGAN PLANTS IN PRINT

**New Literature Relating to Michigan Botany**

For description of this series, see this journal 26: 174. 1987.

—Edward G. Voss

## C. JOURNAL ARTICLES

Allen, B.H. 1984. Additional distributional records of mosses in Ontario. Bryologist 87: 158–159. [Michigan occurrences are noted for three of the species.]

Bissell, J.K. 1987. A bluegrass new to Ohio: Poa saltuensis Fern. & Wieg. Kirtlandia 42: 53. [Includes mention of Michigan distribution south to Allegan County—to which a collection from Kalamazoo County, identified in 1980, may now be added.]

Cameron, R.G. 1985. Splachnum sphaericum from Isle Royale, Michigan. Bryologist 87: 349–350. [Nearest known previous location for this circumboreal moss was Gillam, Manitoba, 990 km north.]

Chmielewski, J.G., G.S. Ringius, & J.C. Semple. 1987. The cytogeography of Solidago uliginosa (Compositae: Astereae) in the Great Lakes region. Canad. J. Bot. 65: 1045–1046. [Tetraploids are said to range from the Bruce Peninsula "northwest to Manistique" while diploids occur elsewhere. However, no tetraploids are cited from Michigan in the list of chromosome number determinations, nor is the diploid mapped just west of Manistique.]

Demoulin, V. 1985. Stereum fasciatum (Schw.) Fr. and S. lobatum (Kunze: Fr.) Fr.: Two distinct species. Mycotaxon 23: 207–217. [Citations include Michigan collections of *S. fasciatum* in Washtenaw and Livingston counties and *S. lobatum* in Washtenaw Co.]

Demoulin, V. 1987. La chorologie des Gastéromycètes. Mém. Soc. Roy. Belg. 9: 37–46. [World distribution map for *Lycoperdon echinatum* and *L. americanum* shows the latter in Michigan in 7 units of one degree of latitude and longitude.]

Duvall, M.R., & D.D. Biesboer. 1988. Nonreciprocal hybridization failure in crosses between annual wild-rice species (Zizania palustris × Z. aquatica: Poaceae). Syst. Bot. 13: 229–234. [The material studied of *Z. palustris* var. *palustris* came from "Cut River mouth, Roscommon County" (presumably "The Cut" at Backus Creek).]

Freudenstein, J.V. 1987. A preliminary study of Corallorhiza maculata (Orchidaceae) in eastern North America. Contr. Univ. Michigan Herb. 16: 145–153. [Distribution maps, specimen citations, and photos document occurrence in Michigan of both "early" and "late" forms, which are also explicitly compared where growing together on Isle Royale.]

Furlow, J.J. 1987. The Carpinus caroliniana complex in North America. II. Systematics. Syst. Bot. 12: 416–434. [Distribution map for ssp. *virginiana,* the only one in Michigan, shows range in southern half of the Lower Peninsula and western Upper Peninsula; text cites a variant from Hillsdale County, lacking leaf glands.]

Glime, J.M., F.D. Bowers, & A.D. Slavick. 1982. The first annual Midwest Bryological Foray. Bryologist 85: 335–335. [Account, by its organizers, of trip extending from Alger Co. to Keweenaw Co.]

Glime, J.M. 1982. Response of Fontinalis hypnoides to seasonal temperature variation. J. Hattori Bot. Lab. 53: 181–193. [Laboratory studies on material from Isle Royale.]

Kephart, S.R., R. Wyatt, & D. Parrella. 1988. Hybridization in North American Asclepias. I. Morphological evidence. Syst. Bot. 13: 456–473. [Includes considerable data and discussion on *A. exaltata* × *A. syriaca* at the George Reserve, Livingston Co.]

Lewinsky, J. 1985. Range extensions of Orthotrichum pallens Brid. in North America. Bryologist 87: 361–362. [Distribution map includes dots for two previously known occurrences in Michigan.]

Menapace, F.J., & D.E. Wujek. 1987. The systematic significance of achene micromorphology in Carex retrorsa (Cyperaceae). Brittonia 39: 278–283. [Much of the material studied was from Michigan sites, including related species of Lupulinae.]

Miller, N.G., & R.P. Futyma. 1987. Paleohydrological implications of Holocene peatland

development in northern Michigan. Quat. Res. 27: 297–311. [Historical study from deposits at Gates Bog and Gleason Bog, Cheboygan Co.]

Mitchell, R.S. 1988. The identity of Thalictrum confine (Ranunculaceae). Brittonia 40: 298–305. [Includes this taxon within a polymorphic *T. venulosum,* recommending recognition of no varieties; "Michigan" is mentioned several times, without any explicit citations nor any observation on the tendency of our specimens to have glandular leaves and to intergrade with other species.]

Pellmyr, O. 1985. The pollination biology of Actaea pachypoda and A. rubra (including A. erythrocarpa) in northern Michigan and Finland. Bull. Torrey Bot. Club 112: 265–273. [Michigan portion of the work was done in Emmet and Cheboygan cos.]

Porter, L.J. 1981. Geographic races of Conocephalum (Marchantiales) as defined by flavonoid chemistry. Taxon 30: 739–748. [One of the 36 collections reported on was from "Bert Lake," Michigan (presumably Burt Lake in Cheboygan Co.)]

Roberts, M.L., & R.R. Haynes. 1986. Flavonoid systematics of Potamogeton subsections Perfoliati and Praelongi (Potamogetonaceae). Nordic J. Bot. 6: 291–294. [Much of the material studied of *P. praelongus* and *P. richardsonii* was from Michigan—localities not specified.]

Rohrer, J.R. 1983. Sporophyte production and sexuality of mosses in two northern Michigan habitats. Bryologist 85: 394–400. [Differences in sporophyte production were minimal in aspen forest and conifer swamp in Cheboygan Co.]

Rosatti, T.J. 1988. Pollen morphology of Arctostaphylos uva-ursi (Ericaeae) in North America. Grana 17: 115–121. [Illustrations of smiling pollen grains, including ones from Emmet and Cheboygan counties, support position not to recognize formal infraspecific taxa in this species.]

Semple, J.C., & J.G. Chmielewski. 1987. Revision of the Aster lanceolatus complex, including A. simplex and A. hesperius (Compositae: Astereae): A multivariate morphometric study. Canad. J.Bot. 65: 1047–1062. [Outline maps indicate Michigan occurrence of var. *lanceolatus* (= *A. simplex*), var. *hirsuticaulis* (although type material from Otsego Co. was not used in the multivariate analysis), var. *interior,* and var. *latifolius.*]

Shaw, A.J., & W. Shaw. 1982. Noteworthy records of mosses from Michigan. Bryologist 84: 557–559. [Five species, 3 of them new to the state, reported from Washtenaw Co. (though county is never mentioned); 1 of the others previously known only from Mackinac Co., and the fifth known from several localities in southern Michigan.]

Smith, H.V., & N.S. Weber. 1987. Observations on Lepiota americana and some related species. Contr. Univ. Michigan Herb. 16: 211–221. [Specimens of *L. americana* and *L. sanguiflua* cited from Michigan.]

Sork, V.L. 1984. Distribution of pignut hickory (Carya glabra) along a forest to edge transect, and factors affecting seedling recruitment. Bull. Torrey Bot. Club 110: 494–506. [Work done at Haven Hill, Oakland Co.]

Southwick, E.E. 1983. Nectar biology and nectar feeders of common milkweed, Asclepias syriaca L. Bull. Torrey Bot. Club 110: 324–334. [Much of the field work was done at the University of Michigan Biological Station.]

Soule. J.D., & P.A. Werner. 1981. Patterns of resource allocation in plants, with special reference to Potentilla recta L. Bull. Torrey Bot. Club 108: 311–319. [Populations studied were in Kalamazoo Co.]

Stalter, R. 1983. Production of viable seed by the American beech (Fagus grandifolia). Bull. Torrey Bot. Club 109: 542–544. [Two of 26 localities from which data were obtained were "Salem Township" (presumably the one in Washtenaw Co.) and East Lansing.]

Taylor, J. & L. W. Mericle. 1982. Pitting of cells in the carpocephalum stalk of Conocephalum conicum (L.) Dum. Bryologist 85: 115–117. [Material studied came from vicinity of University of Michigan Biological Station.]

Threadgill, P.E., J.M. Baskin, & C.C. Baskin. 1979. Geographical ecology of Frasera caroliniensis. Bull. Torrey Bot. Club 106: 185–188. [Distribution map includes dots in southern Michigan.]

Threadgill, P.E., J.M. Baskin, & C.C. Baskin. 1981. The floral ecology of Frasera caroliniensis (Gentianaceae). Bull. Torrey Bot. Club 108: 25–33. [Includes quotation from Hanes & Hanes on flowering in Kalamazoo Co.]

## REVIEW

EDIBLE WILD PLANTS OF THE PRAIRIE: AN ETHNOBOTANICAL GUIDE. By Kelly Kindscher. University Press of Kansas, 329 Carruth, Lawrence, KS 66045. 1987. x + 276 pp. $25.00 hardbound, $9.95 paperbound.

A book which combines many scientific sources with an author's simple experiences is apt to draw a mixed review. Unfortunately, historical statements are made even when no source of information has been found: "While there is no record of the use of saltbush by Indians of the Prairie Bioregion, it was almost certainly a food."

Ms. Kindscher's expertise is centered around an 80-day hike across Kansas and eastern Colorado, and through lessons from her father while fixing fences during her childhood. "My hope is that the stories and songs of the plants in this book will inspire others to learn more about the prairie and its heritage." In spite of many appropriate quotes from impeccable sources, the feel of the book remains chatty and a bit provincial, ". . . while laying down and resting amongst the grass and flowers."

Botanical definitions and descriptions are good. About 200 publications are included in the Literature Cited. The book is organized by Latin genus, with 49 plant chapters, 11 grass descriptions, and 22 other minor-use plants. There are no keys and no size indications on the illustrations, which are of varying quality. The text is in two columns, both with ragged right margins. These lines often contain only five or six words and become choppy reading when comments and quotes are of any length.

Within larger genera, a summary for all species within that genus is usually made. In fact, different uses and degrees of edibility are the rule rather than the exception. For example, uses of *Polygonum* spp., *Potentilla* spp., *Pycnanthemum* spp., and *Solidago* spp. vary considerably among members in the genus.

The author's interpretations often detract from, rather than add to, the authenticity of the book: ". . . I have observed groundnuts growing in a seepy, marshy area directly below a petroglyph . . . . It is possible that they were planted there by Indians."

In conclusion, *Edible Wild Plants of the Prairie* is a good source book for the plants of the prairie states as long as several drawbacks are kept in mind. Scanty personal observations would be better left out unless more intensive research is used. Tasting a bit of a plant on a hike does not make one an immediate expert. Historical assumptions about native people should not be included unless they are based on factual references. Since there are no keys, the reader must be able to identify the plant before using the book.

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## REVIEW

MEDICINAL PLANTS OF NATIVE AMERICA. By Daniel E. Moerman. University of Michigan Museum of Anthropology Technical Reports, Number 19. 1986. Two volumes, xix + 910 pp. Available from Publications Office, Museum of Anthropology, University of Michigan, Ann Arbor, MI 48109. $30.00

Native American medicinal uses of plants form an important part of our heritage, and interest in these uses has always been keen among botanists and anthropologists. However data on this topic are both huge in amount and scattered through the literature. Dan Moerman's massive, two-volume compilations, made possible by computer indexing and data storage, gives finger-tip access to much of the available material. 17,634 records make up the compilation, distributed among 2,147 names of plants. Entries are sorted four ways into four large data tables. The first table, and primary arrangement, is by genus and species. This table, plus a brief introduction and the bibliography of nearly 100 items, comprise the first volume of this work. Volume two contains the data sorted three different ways; by use ("indications"), by plant families, and by cultures. A final table of common names completes volume two—at 910 pages for both volumes.

The one thing that would have helped this compilation to be an even finer work is help and advice from a botanist broadly experienced in the North American flora. Dan Moerman correctly notes that taxonomy has progressed greatly, with, of course, substantial changes in scientific names, since early enthnobotanical work—and decries the lack of a flora of North America. He has done a good job of updating names, but much has fallen through the cracks. *Cardamine diphylla,* noted as not being in *Gray's Manual,* is used as an example illustrating some of the complexities of listing various plant names found in this compilation. However, *Cardamine diphylla* is in *Gray's Manual,* but under *Dentaria diphylla,* and is our common Michigan crinkleroot or toothwort. Non-botanists will have to be careful using this book to avoid falling into traps generated by synonymy.

For a 910 page book, $30 is a good deal, as 3.3 cents per page is not too bad, even for a soft cover book. The volumes are sturdily bound, but the book will not stand up to rough or heavy use without soon needing rebinding. Modest problems aside, this is a marvellous reference tool that nobody interested in North American ethnobotany can be without.

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## INFORMATION FOR AUTHORS

THE MICHIGAN BOTANIST is distributed to all members of the Michigan Botanical Club, an organization composed of professionals and nonprofessionals with concerns for conservation and nature study as well as the local flora, as well as to many individual and institutional subscribers domestically and abroad (total paid circulation exceeds 800). Considering the range of interests among members and subscribers, we try to include, in each volume, a wide variety of subjects relating to the major areas of botany.

Articles should include some new botanical information, and pertain to the Great Lakes Region. Notes on techniques useful to the teacher and hobbyist, biographical and/or historical accounts, and nature education are welcomed. Manuscripts of a primarily literary nature, e.g. poetry, are not acceptable.

Be concise. Many readers do not have patience to read through long articles or sentences. Getting to the point quickly will help keep a reader's attention. Furthermore, eight pages are printed without charge; a charge is assessed for pages beyond eight to cover costs.

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*Species* Author(s) (Family). Common Name (if known).

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Collections representing new records in the flora of the Great Lakes

Region, if not already herbarium specimens, must be deposited at a herbarium listed in the *Index Herbariorum*, before the article is printed. A major herbarium in the state or province where the plant was collected is preferable.

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On the cover: *Leadplant* (Amorpha canescens) *at Gourdneck State Game Area, Kalamazoo Co., Michigan. Photographed by Richard W. Pippen, 1978.*

Vol. 28, No. 2

# THE MICHIGAN BOTANIST

March, 1989



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# KATHRYN E. BOYDSTON (1897–1988): MICHIGAN'S FERN HYBRIDIST AND TWO NEW EXAMPLES OF HER WORK

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The person we knew as "Kay" Boydston was for many years one of the driving forces in maintaining public interest in botany in Michigan. Teacher, naturalist, horticulturist, pteridologist—she was all of these and more. A few examples of her publications are cited below. In this brief memorial I want to emphasize the facet of her that I knew best: her work in the study of ferns, and especially the production of experimental fern hybrids of which I shall give a couple of heretofore unpublished examples. Her first cultures began in 1952, when during an American Fern Society field trip she became acquainted with Matt Mann, the treasurer of the Society, who showed her how to collect spores. Every year after that she planted spores, and attempted to produce crosses. The genera *Asplenium* (spleenwort), *Camptosorus* (walking fern), and *Phyllitis* (hart's tongue) especially caught her fancy. As one result of her work, the natural hybrid, × *Asplenosorus boydstonae* K. Walter (× *Asplenosorus ebenoides* × *Asplenium platyneuron*) was named for her because she had produced the hybrid artificially some years before it was actually found in the wild (Walter 1982; Walter et al. 1982). Not all of her hybrids have been reported, and I here illustrate and discuss a couple of these.

Residents of Chicago, Kay and her late husband, Walter, had long maintained a summer home along the St. Joseph River north of Buchanan, where they built living plant collections over the years. In 1941, the Boydstons moved permanently to their summer home, which they named Fernwood. In the years 1949 to 1952, Kay served as a 6th grade teacher at the Webster School in Niles. Their three children, Robert, Barbara, and Donald spent part of their growing-up years in Michigan. In 1964, with the cooperation and financial contributions of Mrs. Mary L. Plym, their property became converted into what is now known as the Fernwood Nature Center, Botanic Gardens, and Arts and Crafts Center, which soon became a place for school and college classes, as well as citizens' groups, not only in natural history and horticulture, but in the arts as well. It seems to be little known among botanists that Kay was skilled at crafts, and had gathered around her many persons of like ability. Kay was the Director of Fernwood from 1964 to 1974, and during this period the area of the Nature Center was increased from 16 to 94 (now 135) acres, and many buildings were constructed. Today Fernwood is considered one of the most successful activities of its type in the Great Lakes area. There are presently over 1500 members of Fernwood, and the program includes some 140 classes serving,

among others, over ten thousand school children. With all of these developments, over many of which she presided, I found it hard to believe that she was able to accomplish as much as she did in her study of ferns and their hybrids.

Kay Boydston included among her many collaborators and friends such botanists as Frederick and Roberta Case, Virginia Morzenti deBenedictus, Dale and Ethelda Hagenah, John T. Mickel, James W. Wells, Warren P. Stoutamire, Edgar T. Wherry, and numerous others. I remember through the years making the acquaintance of a number of botanists for the first time at Fernwood programs. There are currently probably few public gardens in Michigan that can match those of Fernwood. The formal lilac collection is spectacular, as are the rock gardens, alpine collection, and herb garden. The natural areas of Fernwood, including swamps, beech-sugar maple, and oak woods, have been carefully kept in the wild state, but can be observed and studied because of the system of narrow well-planned trails. The clear-water springs along the wooded, somewhat rocky slope down to the shores of the St. Joseph River are notable habitats for various plants. An artificial prairie has been created with many native plains species.

During the time that she was working on the improvement of Fernwood, Kay's major hobby was ferns, not only hardy outdoor ferns but ferns grown indoors, especially those which she attempted to hybridize. In the outdoors group, the collection she made of rare species and natural crosses of woodferns, *Dryopteris*, is still outstanding. In her special little greenhouse, she was especially interested in producing crosses that did not occur in nature. She repeatedly used the famous fertile form (Walter et al. 1982) of the American hybrid, Scott's Spleenwort, × *Asplenosorus ebenoides* (*Asplenium platyneuron* × *Camptosorus rhizophyllus*) as a parent, because it is known only from a single, small locality in Alabama, and would be unlikely to co-exist with other species that she mated it with. Two of these hybrids have already been published on (Wagner & Boydston 1958, 1961). Some of her most interesting ones were evidently weak and they died before we could study them. A few of the peculiar crosses were never identified, (including one that appeared to be a hybrid between *Asplenium* and *Dryopteris*!) Below I present brief descriptions of two of the especially unusual combinations: × *Asplenosorus ebenoides* × *Asplenium ruta-muraria* (wall rue spleenwort), and × *Asplenosorus ebenoides* × *Phyllitis scolopendrium*. So that we could make more detailed studies, Kay had intended to produce more of these hybrids but did not succeed. All we have today are the pressed samples.

Silhouettes of the wall rue hybrid are illustrated in Figure 1. Influences of *Asplenium ruta-muraria* are evident in the long petiole, the finely crenulate pinna margins, and rhomboidal segments; influences of × *Asplenosorus ebenoides* are evident in the relatively undivided frond tip, the somewhat narrowed blade, and the darkly pigmented color of the petiole that sometimes runs all the way to the base of the blade.

The chromosomes of Kay's × *Asplenosorus ebenoides* × *Asplenium ruta-muraria* were difficult to study because of the extremely variable pair-

FIGURE 1. × *Asplenosorus ebenoides* × *Asplenium ruta-muraria*. Note pinnae shapes, coarse cutting, and pinna stalks. The petioles of the largest fronds are 30–100 percent darkly pigmented. Scale = 5 cm.

ing behavior and the problem of spreading them out enough to tell the difference between pairs and singles. Unfortunately the plant died before we were able to obtain more than a few figures, none of them perfect. The three best figures yielded the following estimates:

| Meiotic figure | Pairs | Singles | # Chromosomes |
|---|---|---|---|
| A | 23 | 95 | 141 |
| B | 27 | 90 | 144 |
| C | 35 | 73 | 143 |
| Averages | 28.3 | 86 | 142.6 |

The genomic formula would be one genome (36 chromosomes) of *Asplenium platyneuron* (P), one (36) of *Camptosorus rhizophyllus* (R), and two

(36 + 36) of *Asplenium ruta-muraria* (WW), i.e., PRWW. The last is an autopolyploid. In Europe both the tetraploid and the diploid occur, but in North America only the tetraploid is known. We know from numerous hybrids, wild and experimental, that genomes P and R do not pair with each other. Thus, such pairs as we found in the Scott's spleenwort × wall rue hybrid were between the two W genomes of the latter.

Silhouettes of Kay Boydston's × *Asplenosorus ebenoides* × *Phyllitis scolopendrium* are shown in Figures 2 and 3. This is a particularly interesting synthetic hybrid because it combines three traditional genera—*Asplenium* × *Camptosorus* × *Phyllitis* and thus would be regarded as a trigeneric hybrid (See genealogy in Fig. 4). The plants of this hybrid were extremely vigorous, as shown in specimens from the spectacular plant in Figure 2, the fronds of which reached 50 cm in length! As would be expected, with both *Camptosorus* and *Phyllitis* having simple fronds, the formation of pinnae was slight and confined to only the lower part of the blade, mostly involving but one or two irregular pinna pairs plus a few lobes. In the largest fronds, the rachis was brownish pigmented up to one-half of its length, a feature inherited no doubt from the ebony spleenwort (*A. platyneuron*). The sori are provided with one indusium on one side (as in *Asplenium* and *Camptosorus*) or more commonly two indusia, one on each side (as in *Phyllitis*).

The spores are abortive, and we observed 108 unpaired chromosomes at diakinesis, one set of 36 from each of the three parents. The chromosomes of *Phyllitis* are larger than those of the *Asplenium* and *Camptosorus*. As there were only 36 chromosomes from *Phyllitis*, we can assume that Kay used the typical European diploid hart's tongue rather than the tetraploid American variety. Of the Fernwood hybrids, this one is of unusual interest not only because of its peculiar trigeneric parentage, but also the fact that it has the potentiality of becoming a fertile allohexaploid if the chromosomes are doubled. Thus, in a sense, a new species could be produced.

Not surprisingly, Kay Boydston received many awards for various components of her work from such organizations as the Michigan Horticulture Society, the American Horticulture Society, American Rock Garden Society, Lake Michigan College, and the Michigan Department of Natural Resources. The National Council of State Garden Clubs gave her an award for distinguished research on hybridization of ferns. In her memory there will be constructed at Fernwood the Kay Boydston Fern Conservatory, to be located in the new Visitors' Center that will be built in 1988. The Conservatory will contain an indoor collection of tropical and temperate ferns to complement the outdoor collection. Adjacent to the Conservatory a permanent display is to be assembled and entitled "Ferns as an Inspiration for Arts" and it is planned to have artwork by over one hundred artists on display. The display will thus combine two facets of Kay Boydston's many talents. We will never forget her undaunted enthusiasm and her love of the world around her. She was an individual who never lost her sense of purpose and excitement.

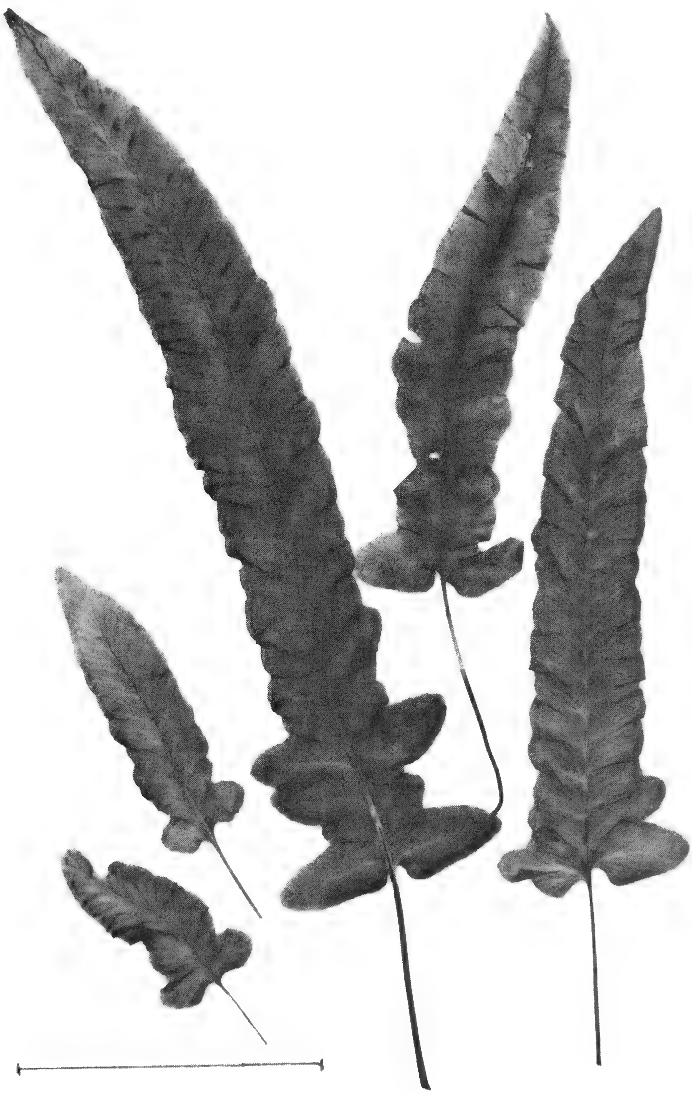

FIGURE 2. Young fronds of trigeneric hybrid (PRS) up to the stage when sori first appear. Scale = 5 cm.

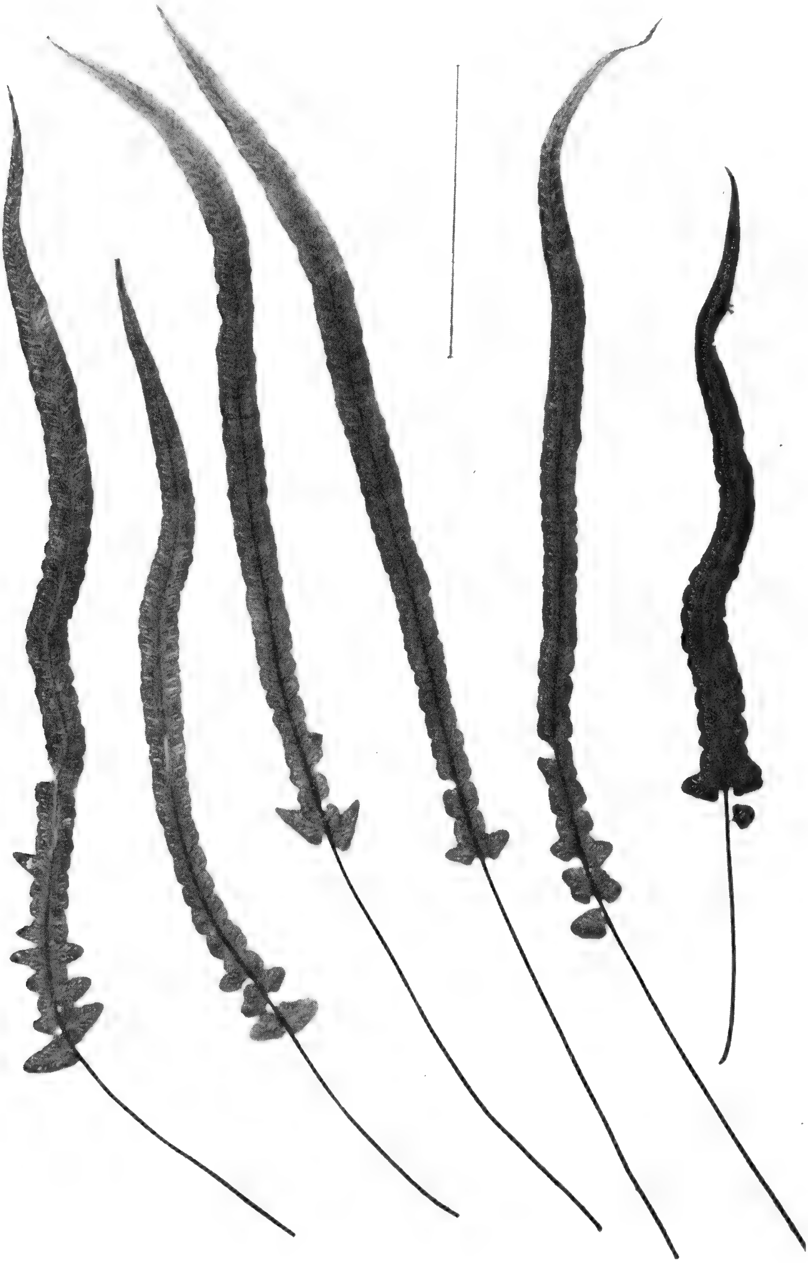

FIGURE 3. Mature fronds of trigeneric hybrid (PRS) showing extreme vigor of growth. Scale = 10 cm.

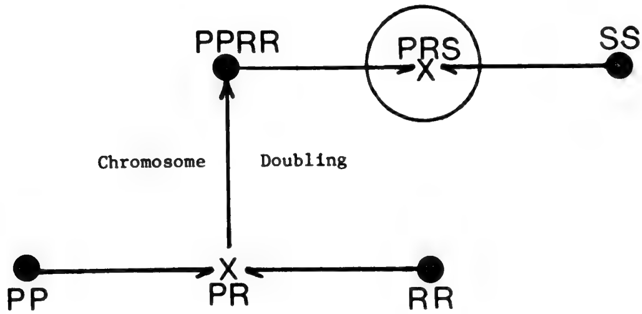


FIGURE 4. Genealogy of a trigeneric hybrid produced in Fernwood cultures and illustrated in Figure 3 and 4. *Asplenium platyneuron* (PP) × *Camptosorus rhizophyllus* (RR) × *Phyllitis scolopendrium* (SS). PR and PRS are sterile, with no chromosome pairing. PPRR is the wild allopolyploid hybrid × *Asplenosorus ebenoides*) from Alabama, in which chromosome doubling occurred; it is fertile, producing viable spores. The sterile diploid form of the same combination, PR, produces abortive spores.

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## PUBLICATIONS OF INTEREST

COMPANION PLANTING: SUCCESSFUL GARDENING THE ORGANIC WAY. G. Franck. 1983. Translated from German. Available through Sterling Publishing Co., Inc., Two Park Ave., New York, NY 10016. $9.99. 128 pp. The book covers vegetable gardening, fruit crops, and ornamentals. While it has some interesting information, it is really more appropriate for the European garden. We have many books written in this country for crop varieties common to North America that are of more help to the home gardener.

NO-DIG, NO-WEED GARDENING. R. P. Poincelot. 1986. Rodale Press, Emmaus, PA 18099-0003. $10.95. 264 pp. The author, a professional horticulturist, explores techniques of no-till gardening applicable to the home gardener. He has tested these techniques. He discusses transplants, soil testing, gardening styles, fertilizers, and weed, insect, and disease control. I personally tried some of the suggestions he makes and they seemed to work for me; some of them appeared to save time. The book would be of particular interest for the elderly gardener whose strength is not what it once was. Overall, the book gives an in-depth look at newer gardening techniques that the busy or infirm gardener might like to explore and is possibly worth buying or at least borrowing from the public library.

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## WILLIAM CAMPBELL STEERE (1907-1989)

William Campbell Steere, the author of the *Liverworts of Southern Michigan*, as well as numerous articles on the bryophytes of the state, died in New York, on February 7, at the age of 81. Born in Muskegon and raised in Ann Arbor, Dr. Steere was educated at the University of Michigan and served as professor of botany, eventually as chairman of the department of botany. He later became dean of the graduate school at Stanford University and director of the New York Botanical Garden. An account of his life and distinguished career as a research botanist appeared in *The Bryologist*, in an issue commemorating his retirement (vol. 80, pp. 662-694.

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# COMPARISON OF TWO NORTHERN WHITE CEDAR (*THUJA*) FORESTS

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## INTRODUCTION

Northern white cedar (*Thuja occidentalis* Linnaeus) forests cover more than two million acres in the Lake States, support commercial lumber production, and are important as winter deeryards (Johnson 1975). Northern white cedar is one of the three dominant tree species in forested wetlands of the Lake States and southern Canada, along with black spruce (*Picea mariana* (Mill.) BSP.) and tamarack (*Larix larcina* (Du Roi) K. Koch.). It forms distinct, near-pure stands (Clausen 1957; Vitt & Slack 1975) that are often described as "impenetrable" (Smith 1952; Barnes & Wagner 1981). Important characteristics of *Thuja* include its shade-tolerance, capacity for vegetative reproduction by layering and ability to regenerate quickly after fire (Curtis 1959; Barnes & Wagner 1981). Although upland stands can reach large sizes (Scott & Murphy 1986), the most common habitat of *Thuja* is in lowland sites along cool, alkaline streams. It has been termed a calcicole because of its requirement of calcareous soils throughout its natural range (Fernald 1919; Harlow 1927).

The purpose of this study was to describe and compare the structures of two forests dominated by northern white cedar. One of the forests occurs as a disjunct, glacial relict, while the other forest is located within the natural range of the species. Comparison of these forests illustrates the stability of structural characteristics for this forest type.

## STUDY SITES

The study sites are located on the native range map of northern white cedar in Figure 1. One site, along the Au Sable River in Hartwick Pines State Park (sections 14 and 15, Grayling Township, Crawford Co., Michigan), is within the primary range in northern lower Michigan. The specific sample site was near the intersection of the Au Sable foot trail and the river. The other site in west-central Ohio is outside the primary range of northern white cedar, about 475 km south of the Michigan site. This site is a glacial relict stand located in Cedar Bog State Memorial (sections 31 and 32, Urbana Township, Champaign Co., Ohio). The forest is maintained by seepage springs arising from underground limestone formations (Forsyth

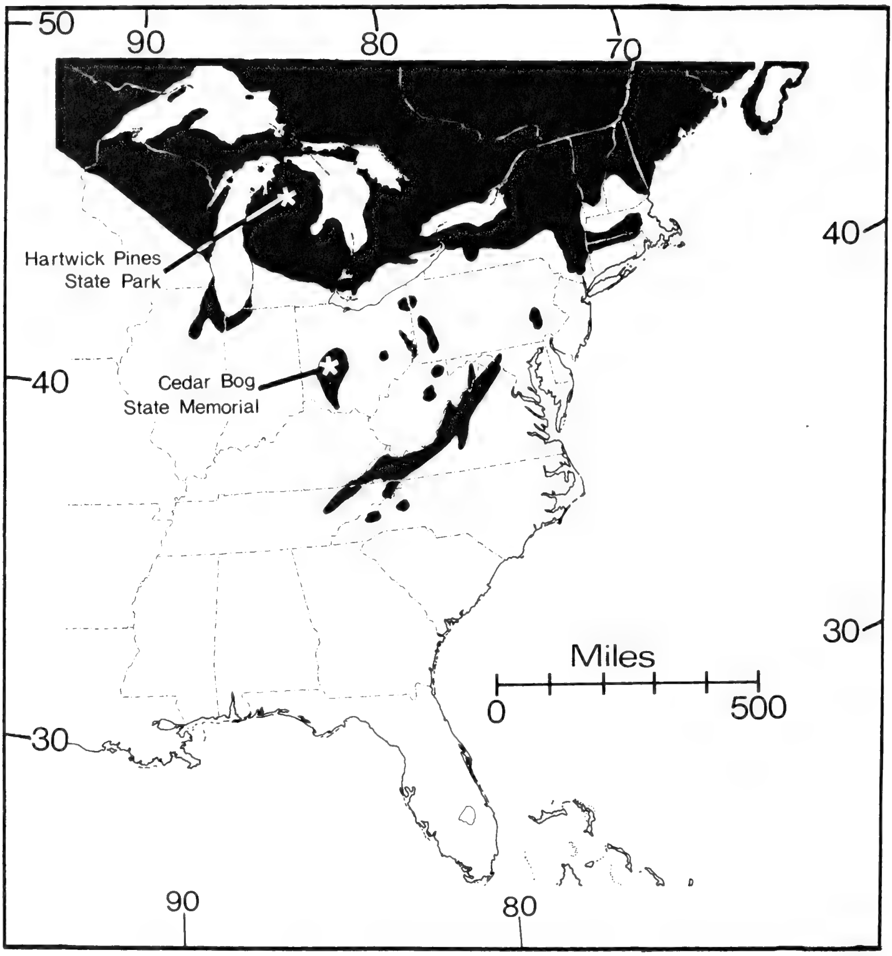


FIGURE 1. Range map of northern white cedar redrawn from Munns (1938) showing locations of the study sites.

1974). The specific sample site was north of Woodburn Road along the east branch of Cedar Run, a tributary stream of the Mad River.

Climate data are listed in Table 1 from recording stations within 15 km of the study sites. The Michigan site is cooler and drier than the Ohio site with more than four times greater snowfall and a growing season nearly two months shorter. The difference in regional climates between the sites is also reflected by their placement in different regional forest types. The Michigan site is in the northern hardwoods forest zone while the Ohio site is in the beech-maple forest zone (Bailey 1980).

TABLE 1. Regional climate comparison of the study sites.

| | Cedar Bog[1] | Hartwick Pines[2] |
|---|---|---|
| average annual temperature | 8.6°C | 7.4°C |
| length of growing season | 163 days | 109 days |
| total precipitation | 94.5 cm | 82.0 cm |
| precipitation as snow | 57.9 cm | 236.2 cm |

[1] Data from Irwin and Urbana, Ohio (NOAA 1980)
[2] Data from Grayling, Michigan (NOAA 1980)

TABLE 2. Tree community structure of the *Thuja* forest at Cedar Bog, Ohio for stems greater than or equal to 10 cm DBH.

| | Basal Area $m^2$/ha | Stem Density stems/ha | Frequency % | Importance Value[1] |
|---|---|---|---|---|
| northern white cedar, *Thuja occidentalis* | 38.2 | 1180 | 100 | 88.1 |
| American elm, *Ulmus americana* | 1.7 | 130 | 70 | 6.8 |
| sycamore, *Platanus occidentalis* | 1.4 | 30 | 30 | 2.7 |
| mulberry, *Morus alba* | 0.5 | 30 | 30 | 1.7 |
| red maple, *Acer rubrum* | 0.4 | 10 | 10 | 0.7 |
| Totals | 42.2 | 1380 | | |

[1] Importance Value = (relative basal area + relative density)/2

## METHODS

Structural characteristics of tree communities at each site were measured with a linear transect of 10 quadrats. Transects were aligned parallel to streams which drained the sites. This design insured direct sampling of the relatively small northern white cedar stand at Cedar Bog, Ohio. Each quadrat in the transects was 10 m by 10 m, making the total sample area at each site 1000 $m^2$ or 0.1 ha. In the transects all trees greater than or equal to 1 cm DBH were identified and their diameters were measured at breast height. Height of the tallest tree in each quadrat was measured with a Haga altimeter.

Measures of forest structure were summarized with Holdridge's complexity index (Holdridge 1967). The complexity index is an aggregate measure which includes the usual measures of basal area and stem density along with tree height and number of species. It is calculated as the product of basal area ($m^2$/0.1 ha), stem density (numbers/0.1 ha), three

TABLE 3. Tree community structure of the *Thuja* forest at Hartwick Pines, Michigan for stems greater than or equal to 10 cm DBH.

| | Basal Area $m^2$/ha | Stem Density stems/ha | Frequency % | Importance Value[1] |
|---|---|---|---|---|
| northern white cedar, *Thuja occidentalis* | 33.1 | 1020 | 100 | 70.3 |
| yellow birch, *Betula alleghaniensis* | 6.9 | 260 | 80 | 16.2 |
| balsam fir, *Abies balsamea* | 2.6 | 190 | 60 | 9.2 |
| red maple, *Acer rubrum* | 3.1 | 30 | 20 | 4.3 |
| Totals | 44.7 | 1500 | | |

[1] Importance Value = (relative basal area + relative density)/2

height (average of the tallest trees in the sample in m) and number of species, all divided by 1000. The complexity index is useful for comparing the structures of forests by aggregating four individual measures into one index value. It has been used most extensively in assessing the structure of tropical forest stands (Holdridge et al. 1971).

## RESULTS AND DISCUSSION

Both forests are dominated by northern white cedar which had importance values of nearly 90% at Cedar Bog in Ohio (Table 2) and 70% at Hartwick Pines in Michigan (Table 3). Elm is the only major sub-dominant at Cedar Bog with a high frequency but a low importance value. Except for mulberry, the sub-dominant species at Cedar Bog are characteristic of lowland sites within the temperate deciduous forest zone. The sub-dominants at Hartwick Pines, birch and fir, are common species in the northern hardwoods forest zone. Red maple, which has a broad geographic distribution, was the only species besides northern white cedar found in both forest samples.

Although the sub-dominant species compositions are different, the total basal areas and stem densities of the forests are remarkably similar. This similarity is largely due to the dominance of both sites by northern white cedar. Apparently the strength of similar site conditions overrides regional climate differences between the sites and causes similar forest structures for larger stem sizes.

However, the structures of the tree populations seem to differ significantly between the sites. Figure 2 shows that there are few *Thuja* stems in the small size categories at Hartwick Pines but many at Cedar Bog. The population structures of Figure 2 suggest that fir is reproducing at Hartwick Pines and may be increasing in dominance while northern white cedar is declining. At Cedar Bog the *Thuja* population seems to be more stable with much reproduction. This conclusion is confirmed by a more detailed study

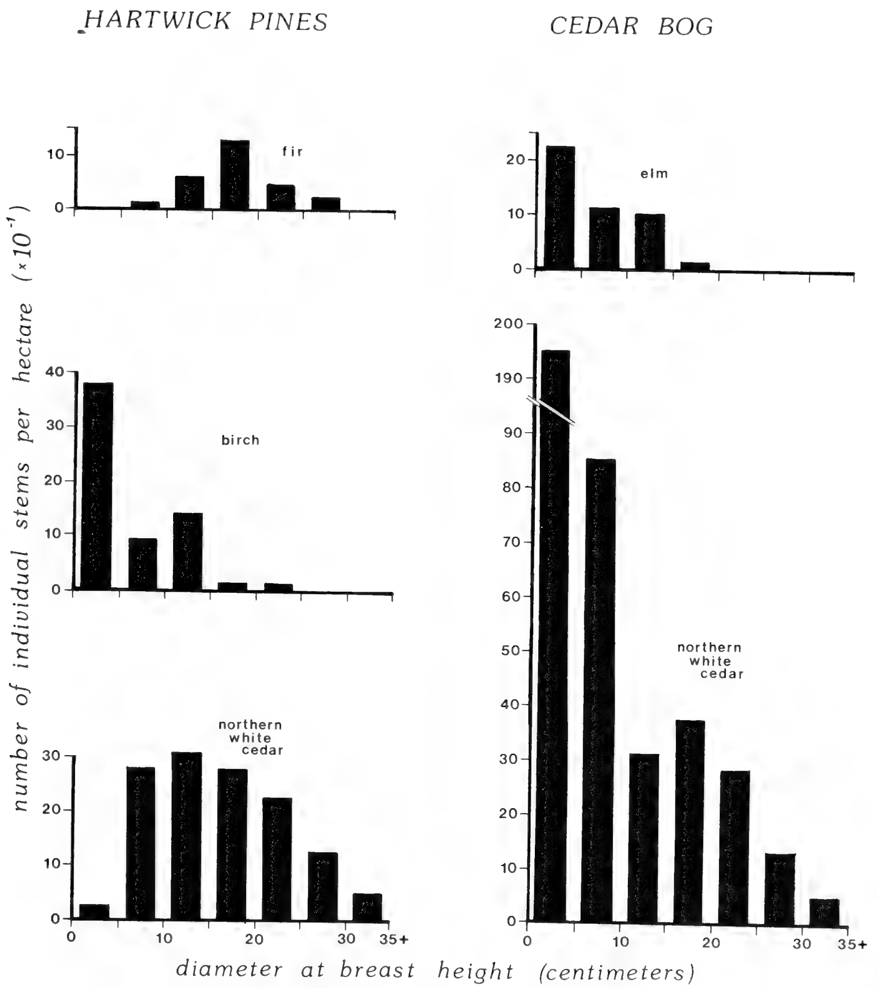


FIGURE 2. Comparison of size class distributions for important tree populations at the study sites.

of the Cedar Bog tree populations by Collins et al. (1979). They suggested that the *Thuja* population is stable and is not being replaced by hardwoods.

Since stand disturbance can be important in *Thuja* regeneration (Curtis 1959), more historical information is needed to understand successional relationships at the study sites and to predict population changes. High densities of small diameter stems of northern white cedar are not uncommon in cedar swamps (Stewart 1925). This condition is often caused by a form of vegetative reproduction, termed layering, which "occurs when low branches touch the soil and send out roots and stems" (Clausen 1957) and

TABLE 4. Measures of forest structure for the study sites and for other forested wetlands.

| | Basal Area $m^2$/ha | Stem Density stems/ha | Tree Height meters | Number of Species | Complexity Index* |
|---|---|---|---|---|---|
| Cedar, Bog Ohio | 48.3 | 4670 | 9.6 | 5 | 108 |
| Hartwick Pines, Michigan | 45.0 | 2220 | 13.3 | 4 | 53 |
| southwestern Michigan *Thuga* forest (Wenger 1975) | 21.7 | 1013 | 11.5** | 8 | 21 |
| southeastern Minnesota *Thuja* forest (Reiners 1972) | 42.2 | 2755 | 9.5 | 9 | 99 |
| Mean of four *Thuja* forests in northern lower Michigan (Schwintzer 1981) | 53.2 | 4552 | 13.3*** | 10.5 | 338 |
| Mean of 20 forested wetlands (Brown et al. 1979) | 44.1 | 2145 | 15.9 | 5.8 | 87 |

* C. I. = (basal area × stem density × tree height × no. of species)/1000 with data from 0.1 ha

** assumed height, mean of height at Cedar Bog and Hartwick Pines

*** assumed height, same as Hartwick Pines

which is initiated by disturbance such as windthrow. Through this form of reproduction, northern white cedar can invade a site or regenerate on a site (see Beals 1965 for an example). Therefore, the large number of small diameter stems found at Cedar Bog may indicate that the stand was recently disturbed leading to a pulse of vegetative reproduction. Likewise, the small number of small diameter stems at Hartwick Pines may indicate that the stand has not been recently disturbed. Without disturbance to regenerate northern white cedar, the stand may be undergoing succession to a community with greater hardwood dominance.

Measures of overall forest structure are listed in Table 4. Basal area and stem density values shown in Table 4 include stems less than 10 cm DBH to allow comparison with data from the literature. For comparison mean values for 20 forested wetlands are included. Complexity indices for *Thuja* forests are remarkably variable, ranging over more than an order of magnitude. The two forests described in this paper (Cedar Bog and Hartwick Pines) fall in the middle of the range. The low value for the southwestern Michigan forest is probably due to disturbance from a highway that was recently built through the stand, as noted by Wenger (1975). The extremely high value for the mean of forests in northern lower Michigan perhaps suggests that these forests occur on the highest quality sites for *Thuja* stand development. However, much of the variation in forest com-

plexity between sites may be due to the inclusion of small stems which reflect recent stand history more than the long-term capacity of the site to support forest structure. For example, the complexity index at Cedar Bog is twice as large as at Hartwick Pines primarily due to the large number of small *Thuja* stems, which increases total stem density at the Ohio site. Complexity indices for the two sites are lower and much closer if calculated only for stems of 10 cm or greater DBH; 27.8 for Cedar Bog and 35.9 for Hartwick Pines. The mean value of the complexity index for forested wetlands from Brown et al. (1979) falls about in the middle of the values for *Thuja* forests. Considering components of the complexity index, *Thuja* forests generally have higher stem densities but shorter tree heights in comparison with the mean values for forested wetlands.

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## REVIEW

THE FLORA OF THE TOBERMORY ISLANDS, BRUCE PENINSULA NATIONAL PARK. University of Waterloo Biology Series Number 31. By J. K. Morton & Joan M. Venn. Waterloo: Department of Biology, University of Waterloo, Waterloo, Ontario N2L 3G1. 92 pp. Cdn. $13.00

The Tobermory Islands in Lake Huron, between the Bruce Peninsula and the Manitoulin Archipelago, appear only on large-scale maps. The largest of the 24 islands that support a vascular flora is only 840 ha, and some are occasionally completely awash. Nevertheless, they well merit the attention given them by Morton and Venn. The flora, although limited by the size of the islands and the harsh environment of the smaller ones, includes many of the rare and disjunct species associated with the northern part of the Niagara Escarpment and with the alvars and fens of the Upper Great Lakes region. Their separation from the mainland has restricted the extent of disturbance by humans. Flowerpot Island, the richest floristically, has been part of Canada's national park system since 1929, and the most of the other islands are now included in Bruce Peninsula National Park.

These islands are discrete land areas, the vegetation and flora of which are now very well known, largely as a result of Morton and Venn's studies. They can, therefore, serve to monitor the long-term effects of natural environmental changes and the indirect, large-scale effects of human activities. The introductory section of this publication contributes superbly to this benchmark function. Comprising 24 pages, it presents accounts of early observations of the islands and detailed records of past human occupation, logging, and other activities. There are also paragraphs on bedrock and Pleistocene geology, climate, gull colonies, and the history of botanical exploration, generally commendably thorough (although I could have cited accounts of botanizing on Flowerpot Island much earlier than 1932). General descriptions are given for 20 plant communities, followed by descriptions of the topography and vegetation of each island.

The list of 542 species (442 native, 100 alien) is accompanied by a table indicating each island from which a species is known. It is apparent from these records that even the most remote islands have been well examined by the authors. The nomenclature is up-to-date, and although any taxonomist is likely to disagree with some choices, extremes of splitting and lumping have been avoided.

There is also a list of unsubstantiated and rejected records, many of the latter having resulted from the reidentification of herbarium specimens. For beginners in floristic studies, this illustrates vividly the importance of documentation and the folly of accepting uncritically all previous reports and identifications.

Eight pages are occupied by 67 photographs of 64 species, taken by the senior author and Donald R. Gunn. These are of excellent quality, but were selected so as to avoid duplication with those in *The Flora of Manitoulin Island* by the same authors. Consequently, while they unquestionably enhance the appearance of the book, they do not necessarily illustrate the most abundant, most readily noticed, or most easily confused species on the islands. Indeed, one illustration is of a fern no longer known from the islands.

In summary, this book reports a study of outstanding thoroughness of an area of major floristic interest. The information is clearly presented in an attractive format, constituting a valuable addition to the literature on the Canadian flora.

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# RARE AND INTERESTING GRASS RECORDS FROM THE NORTHEASTERN LOWER PENINSULA

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During the summers of 1984 through 1988, I have collected grasses somewhat intensively in Alpena and adjacent counties and here report ten species of interest. All are new Alpena County records, and additionally, are not reported in Voss (1972) for any of the adjacent counties: Presque Isle to north, Montmorency to west, or Alcona County to south. The species are: *Alopecurus geniculatus* L., *Alopecurus pratensis* L., *Arrhenatherum elatius* (L.) Beauv., *Briza media* L., *Bromus erectus* Hudson, *Bromus hordeaceus* L., *Calamagrostis epigeios* (L.) Roth, *Cinna arundinacea* L., *Festuca arundinacea* Schreber, and *Puccinellia distans* (Jacq.) Parl. Although none of these species are reported for the first time in Michigan, *Alopecurus geniculatus* and *Bromus erectus* are reported for the first time as established populations, rather than waifs of a few culms from botanical gardens or ballfields. The species are listed in alphabetical order and each treatment includes specimen citations and notes concerning origin, ecology, and distribution. Taxonomy and common names follow that of Dore & McNeill (1980). The herbaria that were consulted for information on these species were BLH, MICH, MSC, and UMBS.

*Alopecurus geniculatus* L. Water Foxtail

**ALPENA CO.**; Alpena Twp., several hundred culms in wet ditch at 2100 Long Rapids Road, 1.2 mi NW of Alpena city limits, 11 Jul 1986, *Garlitz 1568* (BLH, GH, MICH, MSC).

The stand occurs at edge of long sloping lawn and was likely introduced as an adventive in grass seed. The site was visited again on 7 Jun 1988, *Garlitz 2379* (MICH, MSC) and the population is thriving with several hundred culms present. Water foxtail is reported from Michigan in *Manual of the Grasses of the United States* (Hitchcock 1951, p. 359). Voss (1972, p. 191) stated: "*Alopecurus geniculatus* L., by some considered introduced from Eurasia and by others a native species, has been reported from Michigan but no specimens have been found." One additional sheet of *Alopecurus geniculatus* was located at MSC: Oakland Co., 8 Jun 1977, *Churchill 77682*. The herbarium label reads: "In damp low ground at base of scotch pine at W. end of Franklin Village Green near ballfield. Only a few culms. No other plants were found on search." To my knowledge, the Alpena site and this collection by John Churchill represent all that is presently known of this species in Michigan.

*Alopecurus pratensis* L. Meadow Foxtail

**ALCONA CO.**: Greenbush Twp., in rich soil in sunny, moist ditch near farm fields on W side of M-171, 400 ft N of Mikado-Glennie Road at N end of village of Mikado, 8 Jun 1987, *Garlitz 1876* (MICH, MSC). **ALPENA CO.**: Alpena Twp., many clumps on sunny N roadside or Bagley Street, NW city limits of Alpena, 3 Jun 1988, *Garlitz 2363* (BLH, MICH, MSC); Alpena Twp., moist shaded soil on shoulder of US-23, 1 mi S of Squaw Bay (five miles S of Alpena), 3 Jun 1988, *Garlitz 2359* (MICH, MSC).

Meadow foxtail is a Eurasian species that has been introduced across northern North America (Hitchcock 1951, p. 358). After finding and collecting the grass in Alcona County, I found that, having seen it in the field, meadow foxtail is quite easily seen in the roadside vegetation in early June. I subsequently collected this species at two roadside locations in Alpena County and suspect that it is considerably more common than indicated by Voss (1972, p. 191) when it had been collected from only four counties.

*Arrhenatherum elatius* (L.) Beauv. Tall Oatgrass

**ALCONA CO.**: Harrisville Twp., cespitose on loam soil on E roadside of US-23, 1/4 mi N of Harrisville, 2 Jul 1985, *Garlitz 1121* (MICH, MSC). **ALPENA CO.**: Alpena Twp., a few culms found on sandy El Cajon Beach on Lake Huron, 5 mi NE of Alpena city limits, 28 Jun 1987, *Garlitz 2005* (MICH, MSC).

I believe this grass is another European introduction that is undercollected. Voss (1972, p. 168) included but a single record from the Lower Peninsula north of Bay County, a dot for Bois Blanc Island.

*Briza media* L. Quaking Grass

**ALPENA CO.**: Alpena Twp., local but abundant on old Potter Farm on high limestone hillside overlooking valley of the Thunder Bay River on W side of Alpena, 25 Jun 1984, *Garlitz 540* (BLH, MICH, MSC).

Quaking grass has spread over several hundred acres on this calcareous hillside and is an impressive sight when mature in June. The Potter family that owned this property in the early 1900s was prominent and wealthy and enjoyed the luxury of breeding fine horses into the 1920s. Animals and feed were shipped to the farm from distant points (Law & Law 1975, p. 31). It is likely that quaking grass was introduced at that time. Voss (1972, p. 130) cited only two counties (Bay and Oakland, collections made in 1894–1895 and 1906 respectively). *Briza media* has also been collected recently in Cheboygan State Park in Cheboygan County (3 Aug 1983, *Voss 15639* MICH, UMBS).

*Bromus erectus* Hudson Upright Brome Grass

**ALPENA CO.**: Alpena Twp., common but local on thin calcareous, rocky soil over limestone bedrock on hillside (old Potter Farm property) overlooking Thunder Bay River on W side of Alpena, 29 Jun 1986, *Garlitz 1523* (MICH, MSC). **PRESQUE ISLE CO.**: Presque Isle Twp., large clump on gravel, E roadside of US-23, 1/2 mi N of Co. line, ca. 9 mi N of Alpena, 29 May 1988, *Garlitz 2345* (MICH, MSC).

It is interesting that the one Ontario site (near Guelph, Wellington Co., Dore & McNeill 1980, p. 34) where *Bromus erectus* is known to have persisted for several decades matches closely the topography of the Alpena County site. *Bromus erectus* is a European species growing with *Briza media* and was likely introduced in the same way. *Bromus erectus* has likewise spread over several hundred acres and has become the dominant grass where thin, rocky soils exist over bedrock limestone. This species was first identified by Anton A. Reznicek when we visited the site on 27 Jun 1986. Voss (1972, pp. 134–135) cited only Washtenaw County, based on a 1970 collection by Louis Ludwig from the grounds of the University of Michigan Botanical Gardens. This summer (May and June, 1988), I observed *Bromus erectus* at the old limestone quarry at Rockport in Alpena County and collected it across the county line in Presque Isle County. These collections from Alpena and Presque Isle Counties should strengthen the acceptance of this species as a naturalized member of the flora of Michigan.

*Bromus hordeaceus* L. (*B. mollis* L.) Soft Chess

**ALPENA CO.**: Alpena Twp., a few scattered culms in flower beds under honey locust trees at Piper School, N side of Alpena, 4 Jul 1984, *Garlitz 582* (MICH, MSC).

An occasional introduced weed in southern Michigan, it is reported here for the second time in northern Michigan. It is likely that *Bromus hordeaceus* was introduced with potted plants and did not long persist in these flower beds. The species was not located here when the site was checked in July of 1986.

*Calamagrostis epigeios* (L.) Roth Feathertop

**ALPENA CO.**: Alpena Twp., at several roadside locations, 14 Sep 1985, *Garlitz 1306* (MICH); 16 Jul 1986, *Garlitz 1582* (MICH, MSC); and 25 Jun 1987, *Garlitz 2006* (BLH, MICH).

A European adventive reported in Voss (1972, p. 196) for only one county (Clinton Co., *S. N. Stephenson s. n.* in 1968, MICH, MSC). *Calamagrostis epigeios* would appear, from its scattered locations along old trails and gravel roads, to have been introduced several decades ago and is well established on the calcereous sandy soils of Alpena County. *Calamagrostis epigeios* has also been collected in Washtenaw County (*Reznicek & Catling 5191*, 21 Aug 1979, MICH) near the Nichols Arboretum in Ann Arbor.

*Cinna arundinacea* L. Stout Wood Reed Grass

**ALPENA CO.**: Wellington Twp., in mucky soil of floodplain forest under red and silver maple near Truax Creek, 5 miles W of Long Rapids, 25 Jul 1987, *Garlitz 2142* (MICH, MSC).

Common in southern Michigan, stout woodreed is reported by Voss (1972, p. 198) as far north as Tuscola and Oceana counties. *Cinna arundinacea* has also been collected in Menominee County (*Reznicek, Reznicek, & Henson 7438*, 11 Sep 1984, MICH) 14 miles SW of Stephenson near the Menominee River. The Menominee County collection was made 110 miles (177 km) north in latitude of the northern boundary of Oceana County. The Alpena site near Traux Creek is 91 miles (146 km) north in latitude of the northern boundary of Oceana County. These county records make more plausable the specimen labeled as coming from Keweenaw County (*Farwell 749*) in 1890, BLH, MICH) which, understandably, was not mapped by Voss since he considered it to be a dubious record (Voss 1972, pp. 198–199).

*Festuca arundinacea* Schreber Tall Fescue

**ALCONA CO.**: Harrisville Twp., in moist sand of Lake Huron beach, 200 ft N of Main Street on E side of Harrisville, 12 Jul 1987, *Garlitz 2077* (MICH, MSC). **ALPENA CO.**, Alpena Twp., several clumps along calcareous gravel-sand roadside of Bagley Street, 350 ft S of the Bagley Street bridge on W side of Alpena, 3 Jul 1985, *Garlitz 1128* (MICH, MSC); in sunny, sandy soil along S edge of Van Lare Hall, campus of Alpena Community College, 27 May 1986, *Garlitz 1384* (MICH, MSC). **PRESQUE ISLE CO.**: Presque Isle Twp., large clump, 200 ft E of US-23, N side of Rayburn Road, 1 mi S of S end of Grand Lake, 10 Jul 1988, *Garlitz 2506* (MICH, MSC).

Reported in Voss (1972, p. 141) from five counties in Michigan and described as "probably more widespread than suggested by our few records . . ." This is certainly true as this grass is common and spreading aggressively in northeastern Michigan.

*Puccinellia distans* (Jacq.) Parl. Alkali Grass

**ALPENA CO.**: Alpena Twp., many plants in sterile ditch, E side of Bagley Street near Alpena County Road Commission, 10 Jun 1985, *Garlitz 1011* (MICH, MSC).

Voss (1972, p. 148) does not report this grass from north of Bay County in Michigan. Alkali grass is here found in ditches near the road commission building and truck barns where trucks used to salt winter roads are parked. The grass has spread several hundred feet down the rocky ditch near the truck garage. Apparently, *Puccinellia distans* is moving northward and might be expected along any of our heavily-salted highways; it has also been collected along the shoulder of US-2 east of Isabella in Delta County (*Henson 2309*, 1 Jul 1987, MICH, WIS). This species was seen at a second site in the Upper Peninsula by Anton Reznicek (pers. comm.) on June 27, 1986 along the shoulder of M-95 near Sagola on the west side of Dickinson County.

ACKNOWLEDGMENTS

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## REVIEW

PLANTWATCHING: HOW PLANTS REMEMBER, TELL TIME, FORM RELATIONSHIPS AND MORE. By Malcolm Wilkins. Facts on File Publications, 460 Park Avenue South, New York, NY 10016 and Oxford, England. 1988. 207 pp. $29.95 ($39.95 in Canada) hardbound.

Few books describe the processes that control plant growth and development in a manner appropriate for the amateur botanist or gardener, yet an understanding of these processes would prove valuable to both. It always amazes me how many people do not realize that the wheat in the field, the rose in the garden, and the begonia in the pot are all living organisms. The instructor of my introductory botany class told of the student who, after completing the course, said: "I enjoyed the class, but I like living things better." Now, I am sure those reading this review would not make the same mistake, but how many have wondered how plants "know" when to flower? This book is meant to answer such questions, not in great detail, but sufficiently to allow a general understanding.

The text is divided into eighteen chapters: the first four provide a brief overview of plant structure and diversity, with passing nods to algae, mosses, ferns, and fungi. The next fourteen chapters explore various processes, e.g., photosynthesis and seed germination, critical to plant functioning. These chapters concentrate on flowering plants, those most familiar to most readers, with most examples drawn from crop and garden species.

By and large, the text is clear and readable with a distinct British flavor. However, the text at times suffers from excess enthusiasm to entertain. For example, "Fungi are totally unscrupulous in their criminal activities: they even parasitize other fungi—an example of cannibalism at the microscopic level!" (p. 180). The chapter titles are a bit much, too, e.g., "Do Plants Breathe" and "Sensitive and Nervous Plants". Some of the common names may not be known to those not familiar with British usage, e.g., charlock, a yellow-flowered mustard. There are relatively few technical problems in the text. (The definition of perianth (p. 40) is incorrect.)

The text is well illustrated with both photographs and drawings which reinforce the text. The color reproduction is quite good, enhancing the quality of the photographs used. The diagrams clearly illustrate many of the more arcane topics, such as photoperiodism.

The length of the book and the breadth of the subject inevitably lead to

glossing over many areas. Many volumes have been written on topics found in each chapter. Thus, readers are not likely to find exact information on particular species; however they will find a general framework within which to ask questions about plant growth.

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## REVIEW

THE BIOGEOGRAPHY OF THE ISLAND REGION OF WESTERN LAKE ERIE. Edited by Jerry F. Downhower. Ohio State University Press, 175 Mount Hall, 1050 Carmack Rd., Columbus, OH 43210-1002. 1988. viii + 280 pp. $65.00 hardbound.

This volume contains twenty-five papers presented at a symposium on the biogeography of the Lake Erie Islands, held in 1985 at Ohio State University. The book's contents are divided into an introduction and sections on *The Setting* (4 papers), *Near-shore Distributional Patterns* (3 papers), *Insular Patterns: Plants and Invertebrates* (3 papers), *Vertebrate Distributions* (5 papers), *Migration and Immigration* (2 papers), *Succession* (3 papers), and *Physiological Ecology and Genetics* (4 papers). Only five of the papers are botanical in scope: three deal with vegetation succession, one concerns filamentous algae in western Lake Erie, and one applies the theory of island biogeography to the vascular flora of the Erie Islands. I found the four papers on the setting of the Lake Erie Islands (covering geology, climate, physical and chemical limnology, and biological and ecological limnology) to be excellent summaries of the literature on the area. Most of the remaining papers are zoological in scope or discuss island biogeography theory. The contents of the book are very diverse, ranging from mollusks, spiders, and terrestrial isopods, to monarch butterfly migration, melanism in garter snakes, and human impacts on the Lake Erie fish community.

This large (8.5 by 11 inches), hardcover volume is attractively laid out, with numerous figures. Botanists with interests in island biogeography, the islands of western Lake Erie, or zoology, will find this an interesting book. Those with interests in the vascular flora of this region, or floristics in general, will find less of interest.

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# TREE DISTRIBUTION IN SOUTHWESTERN MICHIGAN BUR OAK OPENINGS

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Bur oaks (*Quercus macrocarpa* Michaux) were associated with the prairies of southwestern Michigan, often forming fringing savannas that settlers referred to as bur oak openings. These areas as well as others that were physiognomically similar but not associated with open prairie were also called bur oak plains (Peters 1970). Characteristically, bur oaks grew in relatively pure stands of similar-sized trees (Curtis 1959; Higgens 1840; Hodler et al. 1981).

Tree density in bur oak openings probably varied (Curtis 1959). Density estimates for Michigan oak openings have ranged from about 9.9 trees per hectare (ha) (4 trees per acre) (Wing 1937) to 99–124/ha (40–50/acre) (Beal 1904; Gordon & May 1959). R. Brewer (Hodler et al. 1981) chose 37 trees per ha (15 trees per acre) as the dividing line between oak savanna and oak forest.

Nothing quantitative is known about the pattern (deviation from randomness) of tree spacing in oak openings. Wing (1937) commented that the dark circles he took to be traces of soil developed under the trees of a Jackson County, Michigan oak opening were "astonishingly evenly spaced."

Peters (1970) directed attention to Pioneer Cemetery Park (henceforth, "Cemetery Park") in Kalamazoo, Michigan as offering a possible clue to tree density and spacing in bur oak openings. He wrote:

> "Since the cemetery was set aside in 1833, these burr [sic] oaks may be those that were present on the site at that time. Their distribution gives some indication of the spacing of the burr oaks on the "burr oak plain" on which the village of Bronson [the original name of Kalamazoo] was located. In 1831, because the burr oaks were very small, and there was little undergrowth, the site of Bronson was said to resemble an "old apple orchard."

This study investigated southwestern Michigan bur oak openings by (1) measuring density, composition, and spacing of the trees at Cemetery Park as a possible reflection of original conditions; (2) considering historical events that could have affected the trees of the park; and (3) compiling data from the original land survey to establish presettlement characteristics of bur oak areas throughout Kalamazoo County.

## METHODS

Cemetery Park lies between South Westnedge and Park streets and between Newell and Park Place. It is maintained by the city of Kalamazoo. Sidewalks surround the area and also divide it diagonally into quarters. This study was restricted to the area within the bordering sidewalks even though a few trees of similar size grow on land adjacent to the north.

Data were taken as follows: On 25 May 1971, all trees in the park were identified to species and measured (diameter at breast height, dbh). Also, the distance from each tree to its nearest neighbor was measured to determine pattern using the Clark-Evans method (Clark & Evans 1954). Directions for applying this method are given in Brewer and McCann (1982). Donnelly's (1978) correction for edge effect was applied (Brewer & McCann 1985; Sinclair 1985). All measurements were taken with steel tapes.

To determine tree composition and density of Kalamazoo bur oak openings prior to settlement, the notes of the original land survey, taken in 1827, were used (Cottam 1949; Bourdo 1956). Data was recorded from all section corners and quarter-section points located in the vicinity of historic prairies and oak openings within Kalamazoo County (Hodler et al. 1981) where one or both witness trees were bur oaks. Occasional tree pairs in these areas lacked bur oaks; we did not include these in our samples.

We recorded land survey data separately for "bur oak opening" and "prairie." The latter included points within the historic prairies (Hodler et al. 1981), as indicated by the surveyor's comments. Trees tended to be far from the section corner or quarter-section point, often more than thirty meters and, in one case, nearly a half-kilometer. Usually in these cases, the two witness trees were in the same direction from the point, back toward the edge of the prairie.

Species, distance, and bearing were recorded for both witness trees at each point. Density was calculated for the bur oak opening sample using the random pairs method (Cottam & Curtis 1949, 1956). Points found not to satisfy the 180°exclusion requirement (Cottam 1955) were omitted.

Reports of the Committee on Public Grounds and Buildings of the city of Kalamazoo from 1874 to 1950 were examined to discover if care given to the park might have affected the vegetation.

## RESULTS

### *Tree Distribution in Cemetery Park*

The dimensions of Cemetery Park were 85.9 meters (m) (north-south) by 104.5 m (east-west). Within the .90 hectares (2.2 acres) grew 57 trees or 63.5 per ha (25.9/acre) (Table 1). Of these, 67% were bur oak, and the rest were black oak (*Quercus velutina* Lam.), white oak (*Quercus alba* L.), and shagbark hickory (*Carya ovata* [Mill.] K. Koch). The largest tree in the park was a black oak 94.2 centimeters (cm) dbh. The sizes of the trees within a species were fairly uniform. This was particularly true for bur oak; more than one-third were in the range between 66 and 73 cm dbh. Mean diameters (extremes in parentheses) were bur oak 68.6 cm (48.5–87.9), black oak 76.2 cm (60.2–94.2), white (56.4–87.6). The single hickory was 57.7 cm dbh.

The sum of the 57 nearest neighbor measurements ($T$, in Donnelly's [1978] notation) was 522.5 m. The expected sum, if the distribution were random [$E(T)$], was 357.7 m and var. $T$ was 807.9 m. $T - E(T)/\sqrt{Var.\ T} = +5.80$ indicating significantly ($P<.001$) non-random distribution in the direction of evenness.

Two bur oaks were removed by the city in recent years. A tree cut in 1985 (diameter unrecorded) had about 130 annual rings suggesting that it

TABLE 1. Number of trees by diameter class in Pioneer Cemetery Park, Kalamazoo, Michigan.

| | DBH (Centimeters) | | | | | |
|---|---|---|---|---|---|---|
| Species | 38–50.7 | 50.8–63.4 | 63.5–76.1 | 76.2–88.8 | 88.9–102 | Total |
| Bur Oak | 2 | 9 | 17 | 10 | - | 38 |
| Black Oak | - | 2 | 3 | 3 | 2 | 10 |
| White Oak | - | 2 | 4 | 2 | - | 8 |
| Shagbark Hickory | - | 1 | - | - | - | 1 |
| Totals | 2 | 14 | 24 | 15 | 2 | 57 |

may have started growth not long before 1855. A 1986 tree, 129 cm on the stump, had 124 evident rings. The additional decayed and hollow portion in the center would have contained an additional 39 years of growth, based on simple proportionality. This tree, then, began growth well before 1862 and possibly before 1823. The 129 cm stump translates to a dbh of about 79 cm based on measurements of five similar-sized trees. Consequently, the largest bur oaks in the park in 1971 (Table 1) might well have been 180 years old, suggesting establishment prior to 1800.

Examination of the surveyors' notes confirms Peters' observation (1970) that the park area was originally part of a bur oak plain that encompassed much of the city of Kalamazoo. Surveying a line from south to north John Mullett recorded "Entered Br Oak Plain" at a location 866 ft (264m) south of the park. He did not change this notation until he wrote "Entered Wt Prairie" 1.4 miles (2.3 km) north. The northwest corner of the park lies near the midpoint of the north-south boundary line between sections 21 and 22. At this point, surveyor Mullett recorded two bur oaks of 8 and 10 inches (20.3 and 25.4 cm) diameter. The trees were 61.4 feet (18.7 m) apart.

### *History of Disturbance at Cemetery Park*

The first plat of the village of Kalamazoo dates from March 1831, although a trading post 2.6 km northeast of Cemetery Park was in operation as early as 1823 (Dunbar 1969). Cemetery Park was established in 1833 at the southwest edge of the village as its first graveyard, called South West Street Cemetery (Praus 1959). More than 500 persons were buried in approximately 3 acres until the cemetery was closed by the Board of Health in 1862. Many of the bodies were then removed to newer, less crowded burial grounds. From 1862 to 1884, the site "went to seed" (Praus 1959). The report of the Committee on Public Grounds and Buildings for 1885 stated that "the old West Street Cemetery has been graded ready for seeding. The superfluous trees have been removed and those remaining trimmed

TABLE 2. Percentages of pairs in which the second tree was various species (first tree, bur oak).

| Second Tree | Cemetery Park | Bur Oak Openings* | Edge of Prairie* |
|---|---|---|---|
| Bur Oak<br>*Quercus marcrocarpa* Michaux | 58.3 | 68.9 | 82.1 |
| White oak<br>*Quercus alba* L. | 25.0 | 15.6 | 2.6 |
| Black oak<br>*Quercus velutina* Lam. | 12.5 | 2.2 | 0.0 |
| Hickory** | 4.2 | 8.8 | 2.6 |
| Yellow oak<br>*Quercus muhlenbergii* Engelm. | 0.0 | 2.2 | 12.8 |
| Red Oak<br>*Quercus borealis* Michaux | 0.0 | 2.2 | 0.0 |
| Sample Size | 24 | 39 | 45 |

*Data from the original land survey.
**Shagbark Hickory in Pioneer Cemetery Park; no distinction made among the various hickory species by the original land surveyors.

up." In 1887 further tree trimming was proposed to "facilitate the growth of grass" because of lack of sunlight on the ground. In 1894 "several trees" were removed from Cemetery Park and other parks and the committee recommended that more be taken out because of lack of sunlight on the ground. In 1895 the committee again recommended that more trees be taken out but it was not recorded if this was carried out.

*Bur Oak Openings of the Original Land Survey*

The "prairie" sample is indicative of the composition of trees forming the immediate prairie fringe (Table 2). The "bur oak opening" sample gives the composition of trees away from open prairie. Differences between the two are not significant at the .01 level ($\chi^2 = 5.21$, 2 df, $P < .1$; all species other than bur oak and white oak were placed in an "other" category for purposes of the test). Note that the percentages in Table 2 are for the second tree in pairs where the first is bur oak. For this reason, they are not estimates of the overall composition of the vegetation but instead understate the percentage of bur oaks. If there were no pairs in which neither tree was a bur oak (which was not the case), the actual percentage of bur oak in the vegetation in any of the categories in Table 2 would be given by the formula

Percent bur oak = (percent bur oak in Table ÷ 2) + 50%.

In all, 33 pairs from the "bur oak opening" sample were available for determining random pair distances. These involved nine sites for which densities were calculated separately. Mean density for the nine sites was 7.2 trees/ha (standard deviation = 7.51). Densities by site ranged from 1.7 to 24.0 trees/ha (0.7 - 9.7 trees/acre).

For the bur oak opening in which Cemetery Park is now located, 7 points were available. Overall density was 10.4 trees/ha. Calculating density separately for each random pair, the range was 2.7 – 44.5 trees/ha.

## DISCUSSION

Neither tree density nor spacing in Cemetery Park is a reliable indicator of original oak opening conditions. The complex history of the site, including 500 burials and exhumations and at least two episodes of tree removal, precludes any direct connection.

Tree density at Cemetery Park, although within the range of the few rough estimates previously available (Beal 1904; Wing 1937; Gordon & May 1959), is much higher than densities calculated here for primeval bur oak openings based on the original land survey data. It is six times our estimate of average density in the opening where the cemetery came to be located.

Although a tendency toward even spacing might be expected in such a savanna community (and was noted by Wing 1937), the even spacing we found could well be an artifact. Removal of trees to promote grass growth probably removed clumped trees disproportionately.

The ages determined for two trees, together with the general uniformity in tree sizes, supports the idea that many of the trees were present at the time the cemetery was established. Consequently, the tree composition as we recorded it reflects in some way the composition of the original opening. We suspect, however, that it may be biased toward a greater representation of white and black oak.

Tree composition at Cemetery Park was significantly different from the "prairie" sample ($\chi^2 = 48.0$, 2 df, $P < .001$), primarily by having less dominance by bur oak and greater representation of white and black oak. Although the composition for "bur oak opening" is not significantly different from either "cemetery" ($\chi^2 = 1.76$, 2 df, $P > .05$) or "prairie," it is clearly intermediate. It seems possible that the three samples reflect actual environmental differences between (1) the prairie edge (2) bur oak areas remote from the prairie edge and (3) a bur oak area in which some natural processes were suspended or altered by activities associated with settlement. Fire might well be such a process. We would expect fire frequency to be high at the prairie edge, lower within bur oak openings, and lower still in a bur oak area adjacent to a settlement.

We visualize a situation in which tree density increased following settlement near the site, probably because of fire suppression (Cottam 1949; Schroeder 1981). The cessation of fire could also be a factor in the increase

of species other than the exceptionally fire-resistant bur oak. Stout (1946) commented on the increase of black oak in Wisconsin bur oak openings between 1850 and 1890. Black oak is more predominant in southwestern Michigan bur oak areas now than at the time of settlement (Hodler et al. 1981).

The large size of some of the black oaks at Cemetery Park suggests their early presence at the site. This would be consistent with Curtis' idea (1959, p. 336) that black and white oaks were present in presettlement bur oak savannas but as brush with trunks too small for Land Office surveyors to use as witness trees. In the absence of fire, growth to tree size would be rapid. On the other hand, changes in addition to fire suppression accompanied settlement. It would be premature to conclude that changes in numbers or behavior of animals that eat or cache acorns (such as passenger pigeons, *Ectopistes migratorius* L., and fox squirrels, *Sciurus niger* L.) played no role in the post-settlement differences seen at Cemetery Park and other bur oak openings.

The post-settlement fate of many oak openings was conversion to dense oak forest (Beal 1904; Stout 1946; Cottam 1949). Cemetery Park retains a savanna aspect today but not because the site has preserved a captured portion of the original bur oak opening. Rather, today's density and spacing are largely products of the management the site has received as a park.

## SUMMARY

Based on original land survey data, bur oak openings in Kalamazoo County, Michigan, had a density of about 7 trees per hectare (2.9 trees/acre). The most frequent associates of bur oak were white oak and hickory. Pioneer Cemetery Park in the city of Kalamazoo preserves trees that are relicts of the original bur oak opening on which it was established. Tree density here in 1971 was 63.5 trees per hectare (10.5 trees/acre) and the trees were evenly spaced. Neither feature can be taken as an indicator of the original conditions because of various features of the history of the cemetery, including at least two episodes of tree removal, Two-thirds of the trees in the park were bur oak and the rest black oak, white oak, and shagbark hickory. This probably reflects original conditions, but black oak and white oak are probably over-represented relative to primeval openings owing to environmental changes associated with settlement, especially fire suppression.

## ACKNOWLEDGMENTS

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**REVIEW**

MICHIGAN NATURE ASSOCIATION IN RETROSPECT. Celebrating 28 years of preserving Michigan's wild and rare natural lands 1960–1988. Edited by Bertha A. Daubendiek and Edna S. Newnan. 1989 ["1988"]. 100 pp. $32.94 ppd. (from MNA, Box 102, Avoca, Michigan 48006).

This is a stunningly beautiful book! If one wanted just a volume of "coffee-table" quality photography and printing, this would be a glorious presentation of Michigan's wild habitats and their inhabitants. But it is much more than that. It uses MNA sanctuaries to illustrate that diversity and the need to protect it. Originated as a reflection on the first 100 sanctuaries acquired by this citizens' non-profit group, the book by publication time (March 1989) lists 107 sanctuaries and you can be sure the MNA will not rest on its laurels even at that total!

Although state and federal agencies and The Nature Conservancy have dedicated more acres, 107 is an impressive number of preserves, nicely distributed across most of Michigan's principal habitats. Although Curtis' *Vegetation of Wisconsin* is recommended on p. 29, it is not clear what classification of habitats produced the partial list on p. 100 or calls a floating bog mat a "classic northern wet meadow" (p. 49). It is also nowhere clear what species constitute "Michigan's 83 native trees," although p. 43 explicitly excludes certain shrubs, cites "hawthorn" in the singular, and implies that the oak count recognizes two more than *Michigan Flora*, one more than *Michigan Trees*—even if *Q. prinus* is considered native. All 83 (p. 43) or virtually all (p. 86) occur on MNA sanctuaries as do an alleged 82% of native plant species.

My nit-picking eye spotted remarkably few typographical errors (less than 10, of which the least trivial is directing one southeast rather than southwest of Copper Harbor to No. 54) and also remarkably few problems with botanical information. On p. 28 the golden yellow buds indicate bitternut hickory, and on p. 49, both spring beauties are clearly the northern species. The valerian on p. 24 is in fruit, not "perfect flower". Even if *Ranuculus lapponicus* did (unusually) bloom as early as goldthread, that should help, not hinder, identification since it has yellow rather than white flowers. The next closest station for painted trillium (p. 19) is not Vermont; northeastern Ohio, Pennsylvania, and central Ontario are all closer to St. Clair County. *Aster nemoralis* has never been listed as threatened in Michigan, and in the eastern Upper Peninsula where it is frequent in bogs its bloom normally peaks about a month before the September 4 date suggested. Hart's-tongue fern is, unfortunately, not listed as endangered in the U.S.; in fact, the proposal to list it as threatened was only published late in the summer—after completion of official listings of Houghton's goldenrod, Pitcher's thistle, and dwarf lake iris (but January 1988 is said to be the cutoff date for recording Federal status in this volume). *Kalmia augustifolia*, said on p. 67 to grow in large patches in Chippewa County, is an exciting record for the U.P. if documented.

In a book so loaded with stellar color photos, the only one I noted as seriously off-color is *Viola selkirkii*, normally a definite and rather light blue. Sanctuaries, habitats, and persons mentioned are in lists at the end, with page numbers; an index by organisms might have been helpful. A short list of basic references on Michigan flora and fauna might also have been useful for some readers.

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# STATUS OF THE SWAMP ROSE MALLOW, HIBISCUS MOSCHEUTOS L. (MALVACEAE), IN CANADA[1]

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The swamp rose mallow, *Hibiscus moscheutos,* is one of the northernmost members of the the largely tropical and subtropical family Malvaceae and is the only native, extant member of this family occurring in Canada. *Hibiscus moscheutos* is a robust perennial growing to 2 m in height with up to 8 showy blooms found in the axils of the upper leaves. The large hollyhock-like flowers are unmistakable, with the pink or white petals 6–10 cm long. The flowers are hermaphroditic, and as is characteristic of all mallows, the stamens are united into a column arising from the center of the flower. The style protrudes from the tip of the staminal column and is tipped with 5 round stigmas. When not in flower, the combination of tall stature, pubescent oblong or maple-leaf-like leaves, and subglobose capsules is distinctive (Fig. 1).

*Hibiscus moscheutos* is a taxonomically difficult species and in the past has been divided into two separate taxa, with northern plants referred to as *H. palustris* L. or *H. moscheutos* ssp. *palustris* (L.) R.T. Clausen and southern plants as *H. moscheutos* L. or *H. m.* ssp. *moscheutos* (L.) R.T. Clausen (Fernald 1942; Clausen 1949).

The primary characters used to separate these taxa are petal color and leaf shape. *Hibiscus palustris* L. is distinguished by its pink flowers and three-lobed leaves, while *H. moscheutos* L. is characterized by white flowers, with red centers, and lanceolate leaves. While these extreme morphologies are distinctive, populations are often found with various combinations of white and pink flowers with or without red centers and various leaf shapes. This integration is particularly pronounced in a zone extending from New Jersey to Virginia, where the ranges of the two taxa overlap (Blanchard 1976). However, even at the edge of the range, such as in Ontario, populations can be found with variable leaf shapes and flower color. It is therefore best to recognize all these plants as *H. moscheutos* L. without further dividing this species taxonomically (Blanchard 1976). Blan-

[1]Based on a Committee on the Status of Endangered Wildlife in Canada (COSEWIC) report by the author. Copies of the complete report are available at cost from the Canadian Nature Federation, 453 Sussex Dr., Ottawa, Ontario K1N 6Z4. Rare status was approved and assigned by COSEWIC on April 7, 1987.

FIGURE 1. Flower of *Hibiscus moscheutos*.

chard (1976) has also treated the midwestern species, *H. lasiocarpus* Cav., as a subspecies of *H. moscheutos* L., however, this combination has not been validly published.

## DISTRIBUTION

The range of *H. moscheutos* encompasses most of the eastern United States north of Florida and east of the Mississippi River, with a narrowing coastal distribution evident north of Maryland to Massachusetts. The somewhat disjunct populations in southern Ontario, northern New York, Michigan, Ohio, and Illinois are centered around the lower Great Lakes (Fig. 2). In Canada, *H. moscheutos* is confined to the coastal marshes of Lakes Erie, St. Clair, and southwestern Lake Ontario (Fig. 3).

*Hibiscus moscheutos* is also adventive in widely separated parts of western Eurasia such as northern Portugal, southwestern France, northern Italy, and western Georgian S.S.R. It is also known from Africa along the Algerian coast (Blanchard 1976).

Due to the conspicuous nature and local abundance of *H. moscheutos,* its occurrence in Ontario has been known for over 100 years. Swamp rose mallow was first collected at Pt. Pelee by McPherson (9 Aug 1881, MTMG) and Macoun (23 Jul 1892, CAN) in the late 1800s. The latter specimen is an isotype of *H. opulifolius* Greene, a name applied to plants growing along Lakes St. Clair and Erie by E.L. Greene (Dodge 1914). Other early collections are from Fighting Island, Windsor (*Gavin,* Aug 1894, QK), Pelee Island (*Tripp & Medd,* 7 Aug 1913, OAC), Lake St. Clair (*Wood,* 13 Aug

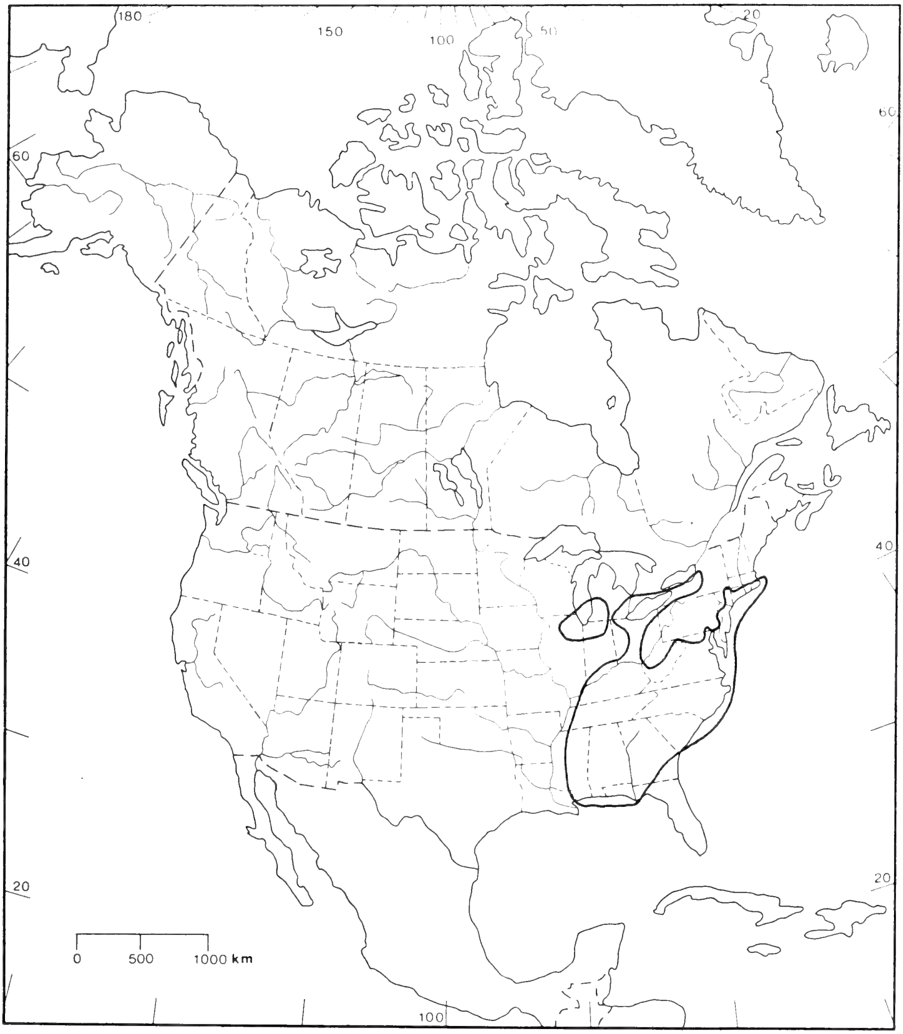


FIGURE 2. Distribution of *Hibiscus moscheutos* in North America, after Ford and Keddy (1987).

1934, DAO), Rondeau (*Cain 1196,* 14 Aug 1934, DAO) and Long Point (*Landon,* 24 Aug 1937, OAC).

## HABITAT

In Canada, *H. moscheutos* is found in marshes that are associated with or have had a recent association with Lakes Erie, Ontario, or St. Clair.

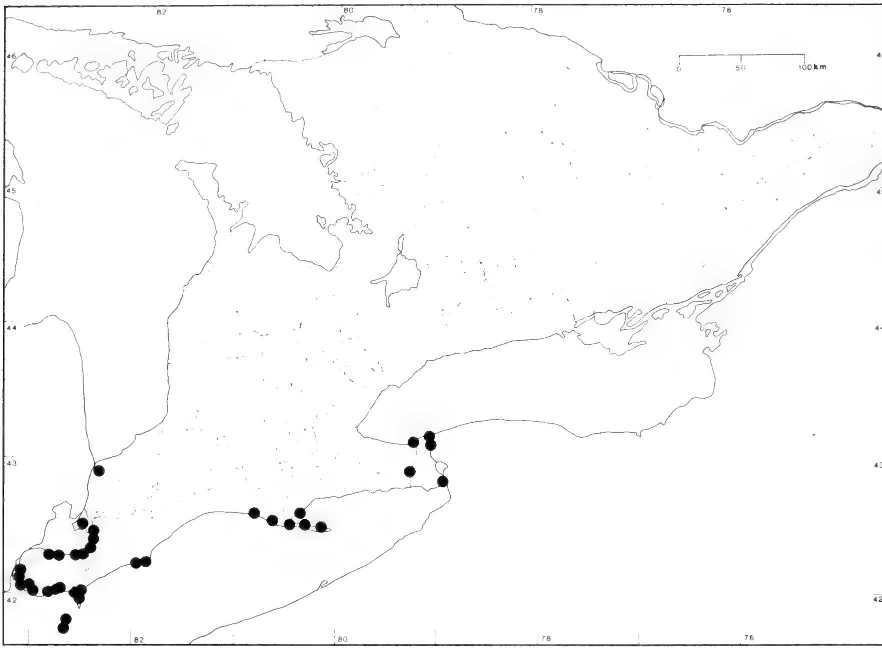


FIGURE 3. Distribution of *Hibiscus moscheutos* in Ontario.

Swamp rose mallow is most common in open wetlands dominated by graminoids such as *Typha* spp., *Scirpus fluviatilis* (Torrey) A. Gray and *Phragmites australis* (Cav.) Trin. ex Steudel, but occasionally occurs in open wet woods, thickets, spoil banks, and drainage ditches.

The importance of water-level fluctuations in maintaining marsh habitat has been well documented in the literature (e.g., Harris & Marshall 1963; Van der Valk & Davis 1978; Keddy & Reznicek 1982) with drawdowns used as a standard management technique. The favorable impact of drawdowns on a Lake Erie population of *H. moscheutos* was described by Farney and Bookhout (1982), who found that plants flourished during periods of low water levels. Thus water-level fluctuations that periodically expose suitable habitat and then re-flood, eliminating shrubs and small trees, are probably necessary for the long-term survival of this species.

## GENERAL BIOLOGY

*Hibiscus moscheutos* is a long-flowering species, blooming from late July until the end of September, with the peak of anthesis reached sometime in the second week of August (Botham 1981; Ford unpublished data). Swamp rose mallow has chasmogamous (i.e., open) flowers with a breeding system that tends to favor outcrossing (Blanchard 1976). However, *H. mos-*

*cheutos* is self-compatible and the large number of flowers open at any one time would suggest that geitonogamy (pollination of one flower with the pollen of another growing on the same plant) is common. The reproductive parts mature simultaneously, but the conformation of the reproductive structures prevents autogamy (Blanchard 1976). Vegetative reproduction appears to be important, with genets (a plant that originates from a seed) able to produce upwards of 50 ramets (vegetative stems with the potential for independent existence) (Ford unpublished data). These genets may in turn become fragmented and dispersed by wind and wave action, facilitating the colonization of new sites.

According to Blanchard (1976), pollination is accomplished primarily by a single species of non-social bee, *Ptilothrix bombiformis* Creson, but this insect has not been reported in Canada (Mitchell 1962). Bees of the genus *Bombus* are known to be infrequent visitors to *H. moscheutos* and perhaps become important pollinating agents in the northern part of this plant's range. In contrast to observations of populations in the United States (Blanchard 1976; Cahoon & Stevenson 1986), insect activity was surprisingly low at many of the stations I have observed in Ontario. While a pollinator-depauperate environment may exist for *H. moscheutos* at the northern edge of its range, seed set appears to be high in many of the herbarium specimens as well as populations examined.

## POPULATION SIZE AND TRENDS

Fifty-seven stations of *H. moscheutos* are known in Canada. Forty of these were verified as being extant during the COSEWIC study. At many of the remaining stations suitable habitat still exists and the species was possibly overlooked. At other stations, such as Iroquois Beach Provincial Park (Elgin Co.), Sarnia (Lambton Co.), and the four Regional Municipality of Niagara stations at Miller Creek, Welland, Niagara on the Lake, and Queenston, swamp rose mallow is probably extirpated.

*Hibiscus moscheutos* varied from an infrequent plant at a station, with only a few ramets, to the dominant species, with hundreds of genets and thousands of flowering ramets present. Swamp rose mallow is most common in the western basin of Lake Erie, with particularly high numbers found at Big Creek, Cedar Creek, and Willowood, in Essex County. On the other hand, populations found in the eastern basin are quite small, and large areas of seemingly suitable habitat are devoid of this species. Crude estimates of population sizes were obtained during the COSEWIC study and are presented in that report (Ford 1985).

All populations visited during the COSEWIC study appeared vigorous and flowered successfully. However, Reznicek (pers. comm., 1985) has noted that plants on Long Point appeared to flower poorly and usually later in the season than their counterparts in Essex County, in the western basin.

Although many stations have been known for over 50 years, little information is available with respect to changes in population size. It would

appear that if habitat requirements are maintained, populations are able to persist for a considerable period of time.

## LIMITING FACTORS

The scarcity of *H. moscheutos* in many wetlands around eastern Lake Erie may indicate that this plant is limited by temperature at the northern edge of it's range. The eastern basin of the lake is significantly colder throughout the year in comparison to the western basin as the result of greater water depth and an influx of cold water and ice during the spring (Burns 1976; Catling & Reznicek 1981; Simons 1976; Sly 1976). These conditions may allow northern plants such as *Thuja occidentalis* L., *Picea mariana* (Miller) BSP., *Betula papyrifera* Marshall, *Larix laricina* (DuRoi) K. Koch., *Corallorhiza trifida* Chatel, *Trientalis borealis* Raf., *Pyrola chlorantha* Sw., and *Aralia hispida* Vent. to persist on areas such as Long Point, and Turkey Point while providing a climate that is for the most part poorly suited for *H. moscheutos.*

Another limiting factor is the introduced loosestrife, *Lythrum salicaria* L., which is common at many *H. moscheutos* stations. In certain wetland areas, this plant is an aggressive weed forming massive colonies that can outcompete native marshland species (Stuckey 1980).

*Hibiscus moscheutos* is host to numerous insect species (Weiss 1919; Weiss & Dickerson 1919) of which *Atomacera decepta* Rohwer (Tenthridinidae), *Chionodes hibiscella* Busck. (Gelechiidae), *Althaeus hibisci* Oliver (Bruchidae), and *Conotrachelus fissunguis* Leconte (Curculionidae) have been discussed as being particularly important parasites of the leaves and/or seeds (Blanchard 1976; Cahoon & Stevenson 1986). It is not known how prevalent these insects are in Ontario.

The greatest potential threat to swamp rose mallow has come, and will continue to come, from the drainage and development of coastal wetlands. Active wetland destruction was noted at four stations during the COSEWIC study, including two stations near the town of Willowood in Essex County, where the highest concentrations of swamp rose mallow occur in Canada. Fortunately, large populations are currently being protected in a number of federal, provincial, and municipal reserves.

## SPECIAL SIGNIFICANCE OF THE SPECIES

Swamp rose mallow can occur in fairly high numbers in the marshes of southwestern Ontario where it contributes to their aesthetics. In association with *Typha* and *Scirpus* spp. it may play a role in shoreline stabilization and the creation of wildlife habitat.

In terms of biological significance, studies of the Ontario populations may provide insights into the effects of factors such as temperature and disturbance on present population sizes, community structure, and distribu-

tional patterns. The pollination biology of *H. moscheutos* has received some attention; however, in Ontario where its principal pollinator may be absent, worthwhile information on alternative pollinator/reproductive strategies could be gained.

## PROTECTION

*Hibiscus moscheutos* has been listed as rare in Ontario (Ford 1985; Ford & Keddy 1987), Canada (Argus & Pryer 1989), and Rhode Island (Church & Champlin 1978) and is considered of special concern in Michigan (Beaman et al. 1985). However, none of these provincial, state, or national designations provides any legal protection for this species or its habitat. It is not protected from international trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Argus 1978).

## EVALUATION OF STATUS

*Hibiscus moscheutos* is considered rare in Canada. Although locally common in some areas, swamp rose mallow is restricted to Great Lakes' coastal marshes, a habitat that has been severely reduced in comparison with its historical range. Threats to this species' survival from wetland development will continue to reduce its range in Canada; however, the large number of stations on government reserves will probably ensure its continued survival in this country.

### SUMMARY

Swamp rose mallow (*Hibiscus moscheutos*) is a large, showy perennial restricted in Canada to the coastal marshes of Lakes Ontario, Erie, and St. Clair. It is widely distributed in the United States east of the Mississippi River and south of Maryland but has a somewhat disjunct distribution in the lower Great Lakes region. Fifty-seven populations of swamp rose mallow are known in Ontario. Most plants occur in open graminoid wetlands but they can occasionally be found in open wet woods and thickets. While swamp rose mallow is locally common in some areas, it is thought that this species' restricted geographic distribution and dependence on Great Lakes marshes (a habitat that has been greatly reduced in comparison to its historic range) warrants that *H. moscheutos* be officially recognized as rare in Canada.

### ACKNOWLEDGMENTS

I am grateful to Cathy Keddy who searched all relevant herbaria for specimens of *H. moscheutos* for the *Atlas of the Rare Vascular Plants of Ontario*. The field assistance and/or information provided by G.M. Allen, M.E. Gartshore, M.J. Oldham, P.D. Pratt, A.A. Reznicek, and D.A. Sutherland were invaluable in the preparation of the original COSEWIC report. I am also thankful to P.W. Ball for his helpful comments and to N.A. Harriman and an anonymous reviewer for their reviews of this manuscript. Financial assistance of the World Wildlife Fund is also gratefully acknowledged.

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# PALE INDIAN PLANTAIN (CACALIA ATRIPLICIFOLIA, ASTERACEAE): A LITTLE-KNOWN PLANT IN MICHIGAN. LIFE HISTORY PART II. SEEDS AND SEED DISPERSAL

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Although the Pale Indian Plantain, *Cacalia atriplicifolia* L., is a striking plant of impressive proportions (to 2 m tall with an inflorescence, of pale cream flowers, to 30 cm wide), it is not well known. In Michigan it occurs chiefly along the edges of woods and as an occasional component of relict prairies. Records indicate that it occurs throughout much of the southern portion of the lower peninsula of Michigan, which is near the northern limit of its range (Athey & Pippen 1987). To gain knowledge of the plant's life history, a field study was conducted on three naturally occurring populations located in Kalamazoo County, Michigan. Aspects of the vegetative growth and production of new plants (ramets) by below-ground structures, as well as sexual reproduction were presented in Part I (Athey & Pippen 1987). In this paper we report results of studies of seed production and dispersal as well as additional considerations of resource allocation. We realize that the "seeds" of *Cacalia atriplicifolia* are actually one-seeded fruits, often call achenes, but technically known as cypselas. For the sake of convenience in this paper, we will refer to these reproductive units as seeds.

## METHODS AND MATERIALS

Inflorescences were collected to determine the number of viable seeds produced per head and per plant. Seeds per head were counted and both seeds and pappus were weighed on an analytical balance, accurate to micrograms.

Seed dispersal distances were studied in the field during peak dispersal periods in August and September of 1974 and 1975, using a technique described by Patricia A. Werner (1974, personal correspondence), with some modifications. A reasonably isolated flowering stem of *Cacalia atriplicifolia*, of a representative height and seed number, was selected for each of two investigations. Tanglefoot, an insect-trapping product, was sprayed on eight 2 m × 0.1 m strips of tree wrap. These were placed on the ground along the cardinal and intercardinal compass points, radiating from the parent plants. At regular intervals of time throughout the seed dispersal period, the strips were examined for the presence of seeds from the test plant. Counts were made of seeds within three dispersal zones, A = 0–0.5 m, B = 0.5–1.0 m, and C = 1.0–2.0 m. from the parent plant. Only mature, developed seeds were counted. Figure 1 graphically depicts the mean total percentage of seeds for the two plants combined that fell on the tape within each of the three dispersal zones.

Distances traveled by seeds of *Cacalia atriplicifolia* and several other species of pappus or coma-bearing seeds under selected wind velocities were determined in the laboratory using a "standard home-model" rectangular 24 inch, 3-speed window fan set 50 cm above the floor. Wind velocity from the fan was determined with a Dwyer Wind Meter (no degree of accuracy stated). Seeds were held at a height of 1 m from the floor and 30 cm from the fan. Following

TABLE 1. Seed (fruit) characteristics of *Cacalia atriplicifolia*.

| | |
|---|---|
| Sample Size: 22 seeds | |
| $\bar{x}$ Seed Weight | 0.004425 g (s.d. 0.00441) |
| $\bar{x}$ Pappus Weight | 0.00033952 g (s.d. 0.00033) |
| Sample Size: 9 seeds | |
| $\bar{x}$ Seed Length | 4.0 mm (s.d. 0.50) |
| $\bar{x}$ Seed Width | 1.5 mm (s.d. 0.28) |
| $\bar{x}$ Seed Depth | 1.0 mm (s.d. 0.44) |
| $\bar{x}$ Pappus Length | 6.5 mm (s.d. 0.65) |

$\bar{x}$ = representation of mean

release, the mean distances traveled by the seeds were recorded. Those seeds which moved upwards and/or to one side, or to the wall beyond 450 cm from the fan, and which, therefore, became difficult to track, were considered to have blown "out of the area".

To investigate seed germination, seeds were cold-stratified for about 120 days at 0.28 degrees C (32.5 degrees F).

## RESULTS

### *Seed Development*

Athey & Pippen (1987) showed that *Cacalia atriplicifolia* requires outcrossing for seed development, and that the plant is clonal. Therefore, it is not surprising that seed set, compared with potential ovules, varied greatly. A count of 19 heads (each head contains 5 flowers), selected at random from all available stems of one population, revealed a mean number of 2.58 mature seeds per head (51.58% of total) and 2.42 infertile seeds per head (48.42% of total, s.d. = 1.47). This ratio appears to be representative of populations observed in the field in general, but more study is needed to determine typical seed set under optimal pollination conditions where members of more than one clone are within reasonable proximity. Heads bearing 5 mature seeds (out of 5 possible) are very common, indicating potential for a high percent of seed development when pollination is optimally effected. Some plants were observed to produce no viable seeds, but these were isolated individuals at considerable distance from the populations at the principal study sites (again supporting the data that the plants are self-sterile).

Seeds mature and are released from late August throughout the remainder of the summer and autumn. At maturity the involucral bracts of the heads become recurved, and the seeds assume an attitude at right angles to the peduncle. Table 1 summarizes seed data from a random sampling of seeds from several populations.

Using the data in Table 1, the ratio of pappus weight to seed weight was calculated as 0.0768. Even though we realize that pappus and comas are structurally different, for a simple comparison, the ratio of coma weight to

TABLE 2. Distances traveled by pappus - or coma - bearing seeds of selected species at different fan settings

| | LOW: 4-7 mi/hr. (6-11 km/hr) | MEDIUM: 7-10 mi/hr. (11-16 km/hr) | HIGH: 10-14 mi/hr. (16-22.5 km/hr) |
|---|---|---|---|
| Species | | $\bar{x}$ cm traveled by seeds | |
| *Cacalia atriplicifolia* | 75 (s.d. 18.9) | 115 (s.d. 28.8) | 168 (s.d. 43.6) |
| *Cacalia plantaginea* | 91 (s.d. 21.2) | 141 (s.d. 40) | 194 (s.d. 53.6) |
| *Taraxacum officinale* | 149 (s.d. 43) | 219 (s.d. 50) | 248 (s.d. 90) |
| *Vernonia missurica* | 102 (s.d. 25.7) | 142 (s.d. 45.6) | 191 (s.d. 54.7) |
| *Prenanthes alba* | 113 (s.d. 20) | 183 (s.d. 43) | 230 (s.d. 60) |
| *Asclepias syriaca* | 214 (s.d. 63.6) | ~13% out of study area* | ~26% out of study area* |
| *Asclepias tuberosa* | 231 (s.d. 65.9) | 309 (s.d. 78.2) | over 50% out of study area* |
| *Cirsium vulgare* | 172 (s.d. 51.5) | 312 (s.d. 70.5) | over 50% out of study area* |
| *Apocynum androsaemifolium* | 326 (s.d. 78.4) | over 50% out of study area* | over 50% out of study area* |

$\bar{x}$ = mean
*no $\bar{x}$ possible
sample size = 100

seed weight of a sample of seeds of *Asclepias tuberosa* L., orange milkweed, was calculated to be 0.5135. This would indicate that there is a lower proportional investment of total plant resources in the seed dispersal structure by *Cacalia atriplicifolia*. While the ratio of pappus weight to seed weight is only one among the many characteristics which influence the effectiveness of a dispersal mechanism, the ratio may be an indication that the pappus-seed structure in *Cacalia atriplicifolia* is not as well adapted for wind dispersal as are those of some other plants (although it may serve the plant in other ways).

### *Seed Dispersal*

Observers who note the coma-bearing seeds of such plants as common milkweed (*Asclepias syriaca* L.) or the pappus-bearing seeds of the common dandelion (*Taraxacum officinale* G. Weber) as they float about on the breezes may assume that any seed with a coma or pappus can be expected to travel considerable distances. However, Grant (1975) cited results of studies which indicated that the bulk of plants' dispersal units end up close to the parent plant.

Results of a laboratory investigation in the present study to compare distances traveled by mature seeds of *Cacalia atriplicifolia* and some other pappus or coma-bearing species under controlled straight-wind conditions are shown in Table 2. The investigation showed that dispersal distances for seeds of *Caclia atriplicifolia* were lower at all wind speeds (although not

necessarily statistically significantly so) than for those of any of the other species tested. Pappus-bearing seeds, in general, showed lower dispersal distances than did those with a coma (except for *Cirsium vulgare* (Savi) Ten. in which the pappus resembles a coma in that the bristles are long, soft, and silky). In addition to moving shorter distances, the seeds of both *Cacalia* species studied had less tendency to re-lift or to be blown farther along the floor after landing. This investigation, therefore, indicates that the pappus of *Cacalia atriplicifolia* seeds has comparatively limited wind dispersal advantages.

Strongly turbulent conditions may vastly modify dispersal distances. It is well known that over sandy, exposed sites, on warm sunny days, warming air rises to a greater degree than it does over cooler, covered areas. While no quantative data were obtained, the senior author has observed that at two of the study sites, which are open and sandy, seeds of *Tragopogon* sp. (goatsbeard), *Cirsium* sp. (thistle) *Lactuca* sp. (wild lettuce) and *Asclepias syriaca* (common milkweed) did rise and leave the area, while those of *Cacalia atriplicifolia* were directed toward the ground.

The longer it takes a seed to reach the ground, the more opportunity there is for dispersal to a greater distance by breezes and gusts of wind. Table 3 shows the mean time required for pappus-or-coma-bearing seeds of ten plant species, including two species of *Cacalia*, to fall to the ground from a height of 1 m in 0 wind velocity (indoors). These data give further reinforcement to the concept that the pappus in *Cacalia atriplicifolia* is not as effective in seed dispersal away from the parent plant as that of some other species.

The limit of dispersal distance of diaspores (the plant parts being disseminated) may be calculated as the greatest distance which 1 % of the seeds of a species can travel using the formula $V_g:X = S_X:S_b$ where:

$V_g$ = the known limit of a well-studied species such as *Taraxacum officinale* (= 10 km)
$X$ = the limit of the species to be determined
$S_X$ = the fall velocity of X, and
$S_b$ = the fall velocity of the known species (Schmidt in Vander Pijl, 1972).

Schmidt considered the average turbulence to be 20 g.cm.sec., with wind velocity of 10 m/sec. Applying the formula we determined that the limit that 1 % of the seeds of *Cacalia atriplicifolia* can travel in the given conditions of turbulence and wind velocity is about 3.4 km. The other 99% would certainly fall far short of that distance.

Many conditions prevent optimal dispersal. The foregoing data for *Cacalia atriplicifolia* apply to mature seeds with fully-spread pappus. Some reproductive structures of this species demonstrate hygroscopic movement. When dry, the pappus hairs are spread out in a nearly full, flattened circle; in conditions of high humidity, the hairs collapse into a more-or-less closed bundle. Similarly, involucres are normally widely spread apart during dry

Table 3. Fall time and velocity of coma and pappus-bearing seeds: Height of Release = 1 m, Wind velocity = 0, Sample size = 10

| Species | Mean Fall Time, in Seconds, Required to Reach Ground | Velocity M/sec |
|---|---|---|
| *Cacalia atriplicifolia* | 1.2 (s.d. .22) | .833 |
| *Cacalia plantaginea* | 1.5 (s.d. .18) | .667 |
| *Vernonia missurica* | 1.5 (s.d. .11) | .667 |
| *Prenanthes alba* | 1.9 (s.d. .05) | .526 |
| *Taraxacum officinale* | 3.5 (s.d. .17) | .286 |
| *Asclepias syriaca* | 3.9 (s.d. .70) | .256 |
| *Asclepia tuberosa* | 4.2 (s.d. .54) | .240 |
| *Lactuca biennis* | 4.9 (s.d. .44) | .204 |
| *Cirsium vulgare* | 6.7 (s.d. 1.02) | .149 |
| *Apocynum androsaemifolium* | 9.5 (s.d. 1.6) | .105 |

conditions, but they, too, become at least partly closed in damp weather. Clearly, dispersal distances would be greatly affected under these conditions. If mature seeds are dislodged from the receptacle under these circumstances (as from a strong tap by the observer) the seeds plummet to the ground, occasionally even becoming lodged within the cauline leaves of the parent plant. Presumably natural circumstances occur that cause this to happen, because it was common to observe seeds so lodged. If damp and quiet weather conditions continued for an extended period of time during the weeks following seed maturation, the pappus disintegrated before the seeds left the parent plant. The result, of course, is diminution of such dispersal advantage as the pappus affords in favorable conditions.

A study of actual seed dispersal of *Cacalia atriplicifolia* was conducted in the field (Fig. 1). A high percent of released seeds fell close to the parent plants, even in optimal seed-dispersal conditions.

Whether fully open or not, the pappus affects the attitude of the seeds with relation to the ground, so that they usually hit the earth with the hilum (attachment) end downward. This is an important consideration in seed germination and establishment of seedlings because the hilum is the chief avenue of water inbibition (Sheldon 1974). Sheldon also noted that seeds of *Sonchus* sp. (sow thistle), which are flat, have an advantage over those of *Taraxacum* sp. (dandelion), which are spindle-shaped, because the former have the hilum region in direct contact with the soil, whereas the latter lie on the ground with the attachment scar off the surface. The shape of the seeds of *Cacalia atriplicifolia* is similar to the shape of *Taraxacum* seeds. It was often observed in the present study that when seeds of *Cacalia atriplicifolia* were lying on a flat surface, such as that of a table, the attachment (= hilum) end was slightly raised, because of their fusiform or ellipsoid shape.

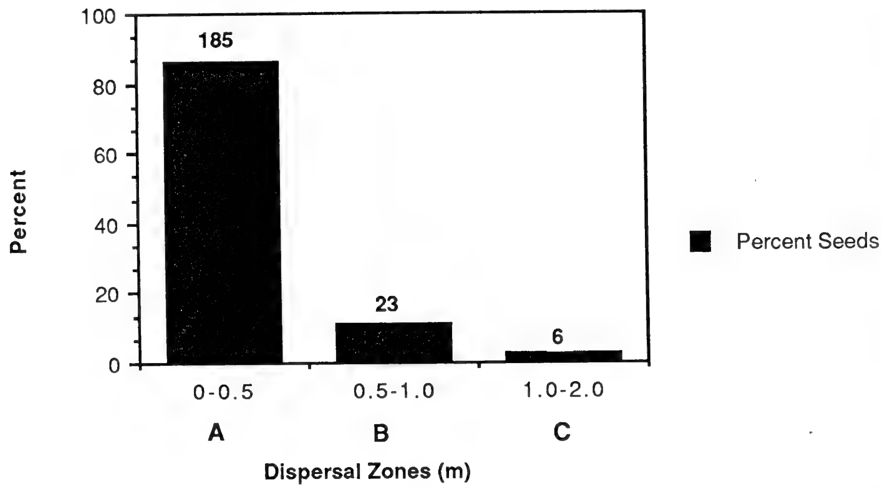


FIGURE 1. Percentage of seeds of *Cacalia atriplicifolia* dispersing in three zones around plant. Numbers above bars are mean numbers of seeds.

Thus, it is all the more important to successful germination that the seeds' landing be directed so that the hilum end has a chance to contact, or slightly penetrate the soil surface. (Soil penetrability is, of course, important also.) The effect of the pappus in *Cacalia atriplicifolia* might be compared to that of the feathers of a badminton bird in that it directs the fall of the seed earthward.

Bakker (1960) discussed the importance of fall velocity to seedling establishment, stating that anemochorous (wind-dispersed) seeds are mainly deposited on the surface of the soil. Field observations of seed dispersal in *Cacalia atriplicifolia* bear out that statement for this species.

After seeds reach the ground various events may change their situation. For example, animal activity (including that of ants, earthworms, and burrowing mammals) often changes the position and location of the seed. Seeds of *C. atriplicifolia* were placed on and near ant mounds, and were observed for at least 15 minutes continuously, again after a few hours, and again on the following day. Ants occasionally tugged seeds aside, but, otherwise showed no other interest in them.

*Seed Viability over Time*

An important characteristic of seeds of *Cacalia atriplicifolia* is their continued viability over a period of time in the ground. Harper (1960) suggested that the number of propagules in the soil at any given time represents a very real and important part of the plant or plant population. Studies of the fate of mature seeds of *Cacalia atriplicifolia* are incomplete,

but preliminary results indicate that a considerable fraction may not germinate in the year following dispersal from the parent plants, but will begin growth the following year.

Of a sample of seeds from 1973 (exact total unknown, but approximately 200), 138 germinated in 1974 and 60 germinated in 1975. So, of 198 propagules that eventually germinated, 30.3% delayed germination until the second year. Because this field experiment was imprecise, a similar study was conducted in the laboratory. Of a total sample of 66 seeds from plants that flowered in 1984, 43 (65.2%) germinated in 1985; 13(19.7%) germinated in 1986; two (3.0%) germinated in 1987; and four (6.1%) germinated in 1988. Four seeds had not yet germinated.

## SUMMARY

Seed counts showed that a highly variable percent of total possible seeds (as represented by potential ovules) actually mature. This number is influenced by many factors, including availability of outcrossing, which was shown earlier to be essential in *Caclia atriplicifolia*. The pappus of the seeds seems inadequate to insure widespread dispersal. Reproductive strategy appears to be directed toward a seed which falls to the ground in a short time within a few meters of the parent plant. (Another integral part of the plant's reproductive strategy is the production of perennating, below-ground, structures and ability to reproduce vegetatively, as reported in Part I of this paper.) The success of the various strategies of *Cacalia atriplicifolia* is attested to by the fact that this species has established populations in at least 19 counties in Michigan, in highly diverse growing conditions, even though we are at or near the northern limits for the species.

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On the cover: *Trout Lily (*Erythronium americanum*) at Baker Woodlot, Michigan State University campus, East Lansing. Photographed by Hannah Priwer.*

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# THE MICHIGAN BOTANIST





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## Flora of Long Point, Ontario

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# FLORA OF LONG POINT, REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK, ONTARIO

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## INTRODUCTION

Long Point, a wilderness of dune, marsh, ponds, forest, and savanna, is one of the most extensive wild areas left in southwestern Ontario, an area where the natural flora and fauna have been reduced to scattered remnants. However, the biological significance of this site extends far beyond the provincial level. The United Nations has designated Long Point as a "Biosphere Reserve" and the International Ramsar Wetlands Conference recognized it as a significant wetland on a worldwide scale. Currently, half of the area is protected and managed under the authority of the Canada Wildlife Act and is one of the more than 40 National Wildlife Areas across Canada protected by the Canadian Wildlife Service.

Located in the Regional Municipality of Haldimand-Norfolk, about 80 km southwest of Hamilton, between 80° 03′ and 80° 28′ W.L. and between

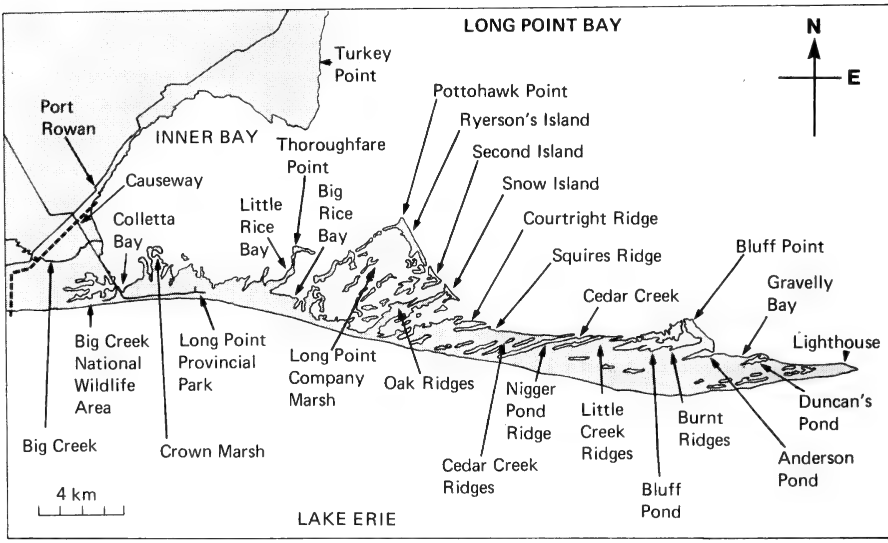


FIGURE 1. Long Point, showing place names used in the text and the boundary of the study area (--).

42° 32′ and 42° 37′ N.L., the Point (Fig. 1) is the largest sandspit on the Great Lakes, extending for 35 km eastward from the north shore into the eastern basin of Lake Erie. The widest essentially dry land surface is approximately 2 km, near Gravelly Bay, but the widest vegetated (mostly marsh and shallow water) area is approximately 5 km wide at Ryerson's Island. The area of the Point is about 6450 ha, although much of this is shallow water. Long Point is geologically very young, having evidently started to form about 4000 years ago (Bradstreet 1977, Davidson-Arnott & Stewart 1987, Wood 1951).

The fact that Long Point is one of the most important natural areas in the Great Lakes region, and is nationally significant in Canada, is a direct result of a strong feeling for wildlife protection on the part of the Long Point Company. This company controlled most of the land from 1869 until 1979, when 3249 ha, extending from Courtright Ridge eastward beyond Gravelly Bay, were donated to the federal government. The Canadian Wildlife Service was chosen by the Company as the recipient because it administered the legislation (the Canada Wildlife Act) that satisfied the conservation goals of the Company. In accord with the terms of the donation, the

Canadian Wildlife Service is charged with the responsibility of maintaining the area in its natural state as the Long Point National Wildlife Area. Consequently, access is restricted and the regulations prohibit various activities including the cutting, picking, removing, or wilfully damaging the vegetation. Biological research is permitted in cooperation with the Canadian Wildlife Service and other landowners. Information is available from the Canadian Wildlife Service office in London, the Big Creek National Wildlife Area headquarters at the base of the Point, the Ontario Ministry of Natural Resources district office in Simcoe, and in McKeating (1983).

Areas at the base of the Point that were purchased by the Canadian Wildlife Service from other owners are also managed as National Wildlife Areas. Other portions of the Point are managed by the Ontario Ministry of Natural Resources (Long Point Provincial Park) and the Long Point Region Conservation Authority. The largest existing private holdings are those still held by the Long Point Company which controls 3000 ha of the marshes south and west of Ryerson's Island for waterfowl production and hunting. In addition, the eastern tip of the Point, where a lighthouse has been operated since 1830, is owned by the Ontario Ministry of Natural Resources and Transport Canada.

Although a number of authoritative faunal studies exist (e.g., Snyder & Logier 1931, McCracken et al. 1981), there is no adequate floristic inventory of the Point. A number of factors have undoubtedly contributed to this situation, in addition to the general inaccessibility of the area. There are many unpublished reports concerning the flora which are incomplete or seriously inaccurate. These reports, despite their deficiencies, satisfied the immediate needs of biologists and managers. Another contributing factor is that the many incomplete studies suggested that Long Point was of limited interest botanically, especially with regard to diversity and rare species, and further, that the work had been done! Not surprisingly, botanists visited and revisited accessible areas well-known for their unusual floristic elements such as the Turkey Point Plains, Rondeau Provincial Park, and Point Pelee National Park. After all, since well-known botanists, such as J.E. Cruise, M. Landon, H.J. Scoggan, H.A. Senn, and J.H. Soper, had all collected plants on Long Point, what else could anyone expect to discover? The answer is a great deal, because none of these botanists ever intended to fully survey the flora and, consequently, never took an organized approach. During our field surveys, we soon realized that Long Point has a distinctive and diverse flora. Not only did we discover many rare species, we also found species that had not previously been recorded in Canada (Reznicek & Catling 1982). It became evident that a current floristic survey of Long Point was needed. Many botanists have contributed to our knowledge (see under "HISTORICAL PERSPECTIVE" and "ACKNOWLEDGMENTS"), and we are pleased to be able to combine all of the available information with our own recent surveys in the production of the present flora.

We hope that this work will be useful not only to researchers or visitors to Long Point, but also to that broader audience that is interested in know-

ing about the botany of one of the finest protected natural areas in the Great Lakes region.

## METHODS

This floristic survey is based primarily on field surveys of the flora we conducted, mostly during the fall of 1979 and the spring and summer of 1980, but with additional trips to the Point occurring until 1988. A special attempt to document spring ephemerals was made in May, 1980. The study area was all of Long Point, including the small developed portion near the base, although emphasis was placed on natural communities. Where the Point abutted the mainland, the boundary was the edge of the open marsh. At the causeway and along the south beach, the boundary was where the line marking the marsh-upland or the marsh-forest boundary crossed. Altogether, we have spent about 36 person-days in the field on the project attempting to survey at least briefly all major habitats throughout the Point at several seasons. While our major collecting was done during years of rising Great Lakes water levels, field work in 1988 occurred during a drought year with falling Great Lakes water levels.

Time was not available for quantitative data gathering, but notes were made on the composition of the vegetation whenever new areas on the Point were first visited. Species lists and records of species abundance in different areas were compiled and form the basis for the comments on abundance and distribution given in the *"Annotated List of Vascular Plants"*.

We attempted to document the occurrence of every vascular plant species seen with an herbarium voucher. As preliminary lists were made, these were given to other botanists who had occasion to visit Long Point so that their collecting could help fill gaps. We searched all published and most unpublished literature on the flora and vegetation of Long Point and drew up lists of reported species. Herbarium vouchers were then sought for any reported species not collected by us. We also searched herbaria for unreported species. Herbaria examined in detail were CAN, DAO, HAM, OAC, and TRT. Additional records were also sought at CCO, CU, MTMG, and TRTE. Methodological comments specific to the checklist are found at the beginning of that section.

To save space, common names are used in the text only for the major woody dominants, in order that community names may be in English. Common names for all species that have regularly used common names are given in the *"Annotated List of Vascular Plants"*, and an index to genera is provided so that common names can be easily found for species mentioned in the text only by scientific name. Sources for common names were Cobb (1963), Fernald (1950), Peterson and McKenny (1968), Petrides (1972), Pohl (1968), and Voss (1972, 1985). Authors for scientific names are given in the *"Annotated List of Vascular Plants"* but not in the text, unless species are mentioned only in the text.

## HISTORICAL PERSPECTIVE

### *1. Botanical Literature Concerning Long Point*

While the extensive bibliography compiled by Canadian Wildlife Service (C.W.S.) (1989) attempts to list all references concerning Long Point, the following brief review is largely confined to published botanical literature; the maze of unpublished reports (some of which are largely inaccurate) are not considered here. We also do not review herein the large number of taxonomic, phytogeographical, and ecological papers that may map or note the occurrence of a particular species at Long Point. We have, however, taken these papers into account insofar as we were aware of them (see also under *"Excluded Species"*).

The first botanical article about Long Point appears to be the brief

note by Leroy J. Boughner (1898). He provided a list of 18 notable or common species and discussed their abundance on the Point. Boughner provided the only report of *Cypripedium arietinum* for the Point and notes *Pterospora andromedea* to be "so frequent . . . as to be almost termed common."

In an introduction to a faunal investigation of Long Point, L.L. Snyder (1931) gave a brief discussion of the vegetation of the Point, concentrating on woody plants. Although not specifically concerned with Long Point, the two floras of Norfolk County, Landon (1960) and Cruise (1969), provided large numbers of citations for the Long Point flora. Unfortunately, many of these citations were not supported by specimens. Quantitative habitat descriptions of a number of plant communities on Long Point were made in connection with breeding bird study plots, and were published in *Audubon Field Notes* and *American Birds* beginning in the 1960's (see McCracken et al. 1981 for a complete list). McCracken et al. (1981) made use of this information in a consideration of breeding bird populations with respect to successional stages in the vegetation. A discussion of Long Point marshes, unfortunately giving very little floristic and vegetational data, was presented by Bayly (1979). This paper also summarized a number of her unpublished reports. Heffernan (1978) and Heffernan and Nelson (1979) presented a substantial amount of data on the vegetation of Long Point, as well as comparisons with Point Pelee National Park and Rondeau Provincial Park. This work provides a useful historical summary of changes in Long Point's vegetation. A vegetation map is given in Heffernan and Ralph (1978). Catling and Reznicek (1981) provided a popular discussion of the flora of Long Point, concentrating on the historical factors that shaped the present day flora and vegetation. New records for Canada resulting from our collections during 1979 to 1981 were also previously reported (Reznicek & Catling 1982). Finally, the very detailed and thorough *Natural Areas Inventory of the Regional Municipality of Haldimand-Norfolk* includes an annotated checklist of the flora (Sutherland 1987) with comments on the overall regional abundance and distribution of species occurring on Long Point.

### *2. Botanical Collecting on Long Point*

Before 1900, there was relatively little botanical collecting on Long Point. People known to have collected on the Point before 1900 include L.J. Boughner (TRT), R.S. Hamilton (OAC), W. Herriott (OAC), J. Macoun (CAN,DAO,TRT), and W. Scott (TRT). Perhaps the most notable find made during this period was Scott's collection of *Pterospora andromedea* in 1898 (TRT), supporting Boughner's (1898) report.

After 1900, Long Point was visited more frequently by botanists and naturalists, and incidental collections of one or a few specimens were made by many people. These are largely summarized by Cruise (1969). Major Long Point collectors during this period include Frére Marie-Victorin and associates in 1932 (MT, DAO, TRT); M. Landon, who collected at least 120

specimens on the Point from the 1930's through the 1960's (HAM, OAC); H.A. Senn and J.H. Soper, who made a major collection of 250 specimens on the eastern end of the Point in 1938 (DAO, TRT); J.B. Falls and W.L. Klawe, who collected several hundred specimens (TRT), also on the eastern end of the Point, in 1951 in association with research on deer mice; and J.E. Cruise, who collected on the Point in the 1950's and 1960's (CU, TRT).

Since 1970, there has been a surge of interest in botanical work on the Point: K.M. Lindsay and I.D. Macdonald collected about 50 specimens on the Point in 1976 (CAN); P.W. Ball, Z.D. Bezdek, and associates collected about 100 numbers near the base of the Point, mostly during the 1970's (TRTE); J. Johnson collected 110 specimens on the Point in 1972 (TRT); and R. Klinkenberg and J. Rhodes collected about 80 specimens while surveying Long Point Provincial Park in 1980 (MICH, TRTE). Several hundred specimens were collected on the Point between 1976 and 1983 in conjunction with geographical, ecological, and zoological surveys, mainly sponsored by the Canadian Wildlife Service. The major collectors were J. Ashenden, J.J. Dean, K. Dewey, S. Heffernan, D.J. Kroetsch, P. Mohr, and B. Ralph (DAO). M.J. Oldham visited the Point several times between 1984 and 1988 and collected several dozen specimens including some valuable new records (CAN, MICH), and D.A. Sutherland collected several dozen specimens on Ryerson's Island and near the base of the Point in 1986 (MICH).

The largest single collection made from Long Point is our own, consisting of nearly 700 specimens collected from 1979 to 1988 (DAO, MICH; smaller sets in CAN & TRT). This is the only collection that was made with the specific intent of documenting the entire vascular flora of the Point. In total, there have been an estimated 2300 specimens of vascular plants collected on the Point. The great majority of these are recent collections and most are from accessible areas near the base of the Point and near cabins.

## FLORA OF LONG POINT

### *1. Synopsis*

The present documented flora of Long Point, 691 species (including 7 named hybrids), is undoubtedly low, due to the lack of a history of continuous floristic work. Additions still come easily. A single two-day field trip in 1988 added 9 species to the flora, albeit mostly sporadic weeds. An additional 12 species[1] were seen by us in the field since 1979, but vouchers could not be collected and thus these species are not included in the annotated list.

[1]*Atriplex prostrata* DC., *Citrullus lanatus* (Thunb.) Matsum. & Nakai, *Euphorbia nutans* Lagasca, *Monotropa uniflora* L., *Potentilla fruticosa* L., *Senecio vulgaris* L., *Silene vulgaris* (Moench) Garcke, *Smilacina racemosa* (L.) Desf., *Sonchus oleraceus* L., *Thalictrum dioicum* L., *Trillium grandiflorum* (Michaux) Salisb., and *Vicia cracca* L.

Taking these factors into account, a good estimate of the actual size of the flora is probably ca. 750 species. This list of the flora is primarily the result of an intensive, but short-term, floristic study concentrating on native habitats. Thus, additions to the list are likely to fall into two major categories: 1) weeds of disturbed sites, especially uncommon and sporadic weeds; and 2) rare native species which occur at low population levels in very local areas or occur sporadically in response to cyclical phenomena such as fluctuating Lake Erie water levels.

As might be expected of a site with extensive areas of non-forest communities, the Cyperaceae and Poaceae, each with 82 species, and the Asteraceae with 73 species are the largest families in the flora. A number of families, however, are under-represented in the Long Point flora. Most notable are the Fabaceae, with only 16 species. A number of characteristic genera of southern Ontario forests, savannas, and prairies are very poorly represented on the Point or altogether absent, including *Desmodium, Lathyrus, Lespedeza,* and *Vicia*. Shrubby Rosaceae are poorly represented, especially *Amelanchier, Crataegus, Prunus,* and *Rubus*. Also poorly represented are Apiaceae, Lamiaceae, and Scrophulariaceae. Factors responsible for the poor representation of certain groups are not clear. Heavy browsing by deer is undoubtedly a major factor in the poor representation of shrubby Rosaceae, and shrubs in general, as well as some forbs (see under *"Some Important Factors Affecting the Vegetation"*). The fact that much of the open upland savanna and grassland on the Point is derived from recently degraded forest rather than being original prairie and savanna may also be a major factor in the poor representation of certain plant groups.

While the plant communities of Long Point have been dramatically altered by logging and fire, intensive human disturbances such as agriculture, road building, and residential development have been confined to small areas. The non-native component of the Long Point flora is thus average, at 20.6% of the total flora, which is in accord with the total of 19.9% for the entire Gray's Manual range (Fernald 1950), and somewhat lower than the figure of 22% for the entire Regional Municipality of Haldimand-Norfolk (Sutherland 1987).

## *2. Rare Species*

The significance of Long Point to the floras of Canada and Ontario is seen in the list of 42 provincially rare species known from the Point (Table 1). The great majority are wetland species or aquatics, again emphasizing the national importance of Long Point's marshes and interdunal meadows. A few rare species, such as *Ptelea trifoliata, Stipa spartea,* and *Strophostyles helvula,* occur on open dunes and beaches and very few, including *Carex artitecta, Corallorhiza odontorhiza,* and *Muhlenbergia tenuiflora,* occur in forests. Three species, *Carex alata, C. nigromarginata,* and *Eleocharis equisetoides,* have been found nowhere else in Canada. Two of these three species were discovered during our field work in 1980 and were

TABLE 1. Plants on Long Point included in the Ontario Rare Plant Atlas (Argus et al. 1982–1987). Species are in the same order as in the *"Annotated List of Vascular Plants."*

| | |
|---|---|
| *Najas gracillima* | *Peltandra virginica* |
| *Sagittaria graminea* var. *cristata* | *Corallorhiza odontorhiza* |
| *Aristida necopina* | *Spiranthes magnicamporum* |
| *Echinochloa walteri* | *Chenopodium foggii* |
| *Muhlenbergia tenuiflora* | *Nelumbo lutea* |
| *Panicum gattingeri* | *Nuphar advena* |
| *Stipa spartea* | *Liriodendron tulipifera* |
| *Vulpia octoflora* | *Crataegus brainerdii* |
| *Carex alata* | *Potentilla paradoxa* |
| *C. artitecta* | *Strophostyles helvula* |
| *C. nigromarginata* | *Linum medium* var. *texanum* |
| *C. tetanica* | *Ptelea trifoliata* |
| *Cyperus erythrorhizos* | *Hibiscus moscheutos* |
| *C. flavescens* | *Cornus drummondii* |
| *Eleocharis caribaea* | *Pterospora andromedea* |
| *E. engelmannii* | *Onosmodium molle* |
| *E. equisetoides* | *Justicia americana* |
| *E. quadrangulata* | *Galium pilosum* |
| *Scirpus smithii* | *Aster dumosus* |
| *Scleria verticillata* | *Bidens coronatus* |
| *Juncus acuminatus* | *B. discoideus* |

reported elsewhere (Reznicek & Catling 1982), and *Eleocharis equisetoides* was rediscovered in 1988.

In addition to the provincially and nationally rare species on Long Point, many of which are of southern affinity, there are a great many species which are rare in the Regional Municipality of Haldimand-Norfolk. Included here are many northern species such as *Carex limosa, Salix cordata, Solidago ptarmicoides,* and *Sparganium minimum.* Table 2 lists all species whose only occurrence within the Regional Municipality of Haldimand-Norfolk is on Long Point. This long list of 60 species emphasizes the distinctive character of the Long Point flora.

### *3. Excluded Species*

Perhaps because there has never been a comprehensive treatment of the flora of Long Point, there are many published reports of species from the Point that are without specimen documentation or based on misidentified specimens. These are listed in Table 3, with the citation of the report and the reason for exclusion. Some of these excluded species are merely undocumented, and the reports may well be correct. However, many of the records noted as being without specimens were presumably based on specimens long ago reidentified and refiled, and thus not easily found in herbaria.

In addition to the published literature that was surveyed for Table 3, there exists a great deal of floristic information in unpublished and very locally distributed sources. These sources include field notes and checklists,

TABLE 2. Native species known in the Regional Municipality of Haldimand-Norfolk (Sutherland 1987, and pers. comm. 1989) only at Long Point. Species are in the same order as in the *"Annotated List of Vascular Plants."*

| | | |
|---|---|---|
| *Sparganium minimum* | *C. artitecta* | *Cerastium nutans* |
| *Potamogeton epihydrus* | *C. crawei* | *Brasenia schreberi* |
| *P. filiformis* | *C. garberi* | *Arabis drummondii* |
| *P. foliosus* | *C. limosa* | *Descurania pinnata* |
| *P. friesii* | *C. nigromarginata* | *Crataegus brainerdii* |
| *P. ×haynesii* | *C. sartwellii* | *Potentilla paradoxa* |
| *P. illinoensis* | *Eleocharis caribaea* | *Linum medium* var. *texanum* |
| *P. nodosus* | *E. equisetoides* | *Ptelea trifoliata* |
| *P. perfoliatus* | *E. olivacea* | *Hypericum kalmianum* |
| *P. robbinsii* | *E. quadrangulata* | *Myriophyllum sibiricum* |
| *P. strictifolius* | *E. quinqueflora* | *M. verticillatum* |
| *Najas gracillima* | *Fimbristylis autumnalis* | *Pterospora andromedea* |
| *Triglochin maritimum* | *Wolffia borealis* | *Onosmodium molle* |
| *Elodea nuttallii* | *Tofieldia glutinosa* | *Utricularia cornuta* |
| *Aristida necopina* | *Pogonia ophioglossoides* | *U. gibba* |
| *Echinochloa muricata* | *Salix cordata* | *U. minor* |
| *Festuca saximontana* | *S. myricoides* | *U. resupinata* |
| *Muhlenbergia tenuiflora* | *Quercus ×deamii* | *Aster borealis* |
| *Stipa spartea* | *Chenopodium foggii* | *A. dumosus* |
| *Carex alata* | *Corispermum hyssopifolium* | *Solidago ptarmicoides* |

internal Canadian Wildlife Service reports, planning reports, theses, private marsh management surveys and reports, local newsletters, etc. These sources are difficult to trace and mostly not refereed. Reports of plant species in them are usually undocumented, and in some instances botanical accuracy has suffered at the expense of overwhelming misinformation. We have not considered these sources in our work in order not to lengthen greatly our already long list of excluded species. All are cited in the recent bibliography by C.W.S. (1989).

### *4. Vegetation Patterns*

There are a number of distinctive plant communities on Long Point. These are particularly well-developed near the tip where succession is a major factor accounting for them. Since the ridges are oriented in a northeast-southwest or east-west direction with the older ridges to the northwest (Fig. 2), it is possible to see several stages of vegetational succession by crossing the Point, for example, at Gravelly Bay, near the eastern end of the Point (Fig. 3). There, on dry sites the youngest dunes are built up by *Ammophila breviligulata* (2 in Fig. 3), which is eventually replaced by Cottonwood (*Populus deltoides*) savanna (4 in Fig. 3), which is in turn quickly invaded by Red Cedar (*Juniperus virginiana*) (6 in Fig. 3). White Cedar (*Thuja occidentalis*), White Pine (*Pinus strobus*), and Red Oak (*Quercus rubra*) then invade the oldest stages of Cottonwood-Red Cedar savanna as Cottonwood dies out (8 in Fig. 3). Sand accumulation virtually

TABLE 3. Plants reported from Long Point, but not accepted here.[1] Species are in the same order as in the *"Annotated List of Vascular Plants."* Under "EXPLANATION", if a specimen supporting the report was misidentified, the correct identification is noted; if the specimen was thought to be mis-labelled, "label error" is noted. In one instance, a reported species is known only from a planted occurrence.

| SPECIES | CITATION | EXPLANATION |
|---|---|---|
| *Equisetum scirpoides* | Cruise (1969) | *E. arvense* |
| *E. sylvaticum* | Cruise (1969) | label error |
| *Taxus canadensis* | Cobus et al. (1965) | no specimen |
| *Sparganium americanum* | Landon (1960), Cruise (1969) | no specimen |
| *S. fluctuans* | Bayly (1979) | *S. chlorocarpum* |
| *Potamogeton alpinus* | Cruise (1969) | *P. illinoensis* |
| *Deschampsia flexuosa* | Cruise (1969) | no specimen |
| *Aristida basiramea* | Catling et al. (1977), Dore & McNeill (1980) | label error |
| *Calamagrostis neglecta* | Klinkenberg & Rhodes (1981) | no specimen |
| *Hierochloë odorata* | Cruise (1969) | no specimen |
| *Andropogon gerardii* | McCracken et al. (1981) | no specimen |
| *Carex angustior* | Cruise (1969) | label error |
| *C. capitata* | Hurst et al. (1979) | no specimen |
| *C. flava* | Cruise (1969) | no specimen |
| *C. intumescens* | Cruise (1969) | no specimen |
| *Eleocharis compressa* | Cruise (1969) | no specimen |
| *E. obtusa* | Klinkenberg & Rhodes (1981) | no specimen |
| *E. ovata* | Klinkenberg & Rhodes (1981) | no specimen |
| *Scirpus olneyi* | Klinkenberg & Rhodes (1981) | no specimen |
| *S. rubrotinctus* | Cruise (1969) | no specimen |
| *Juncus gerardii* | Klinkenberg & Rhodes (1981) | no specimen |
| *J. marginatus* | Brownell & Catling (1987) | label error |
| *J. melanocarpus* | Klinkenberg & Rhodes (1981) | name unknown |
| *Smilacina racemosa* | Schugar et al. (1974) | no specimen |
| *Clintonia borealis* | Cruise (1969) | label error |
| *Zigadenus glaucus* | Cruise (1969) | label error |
| *Sisyrinchium mucronatum* | Cruise (1969) | no specimen |
| *Arethusa bulbosa* | Miller (1974) | no specimen |
| *Cypripedium arietinum* | Boughner (1898) | no specimen |
| *Populus balsamifera* | Klinkenberg & Rhodes (1981) | no specimen |
| *P. grandidentata* | Snyder (1931) | no specimen |
| *P. nigra* | Cruise (1969) | *P. deltoides* |
| *Salix pentandra* | Klinkenberg & Rhodes (1981) | no specimen |
| *Juglans nigra* | Heffernan & Nelson (1979), McCracken et al. (1981) | planted only |
| *Castanea dentata* | Snyder (1931) | no specimen |
| *Fagus grandifolia* | Boughner 1898, Snyder (1931) | no specimen |
| *Quercus bicolor* | Snyder (1931), Hurst et al. (1979), McCracken et al. (1981) | no specimen |
| *Q. velutina* | Snyder (1931) | no specimen |
| *Pilea pumila* | Miller (1974), Nakashima (1973) | no specimen |
| *Comandra richardsiana* | Klinkenberg & Rhodes (1981) | no specimen |

TABLE 3. *Continued*

| *SPECIES* | *CITATION* | *EXPLANATION* |
|---|---|---|
| *Polygonum hydropiperoides* | Klinkenberg & Rhodes (1981) | no specimen |
| *Rumex obtusifolius* | Cruise (1969) | no specimen |
| *Ceratophyllum echinatum* | Cruise (1969) | *Ranunculus longirostris* |
| *Caltha palustris* | Cruise (1969) | no specimen |
| *Ranunculus flabellaris* | Landon (1960) | no specimen |
| *R. trichophyllus* | Dunn & Nol (1977) | no specimen |
| *Thalictrum dasycarpum* | Landon (1960) | no specimen |
| *T. dioicum* | Boughner (1898) | no specimen |
| *Hammamelis virginiana* | Snyder (1931), Cruise (1969) | no specimen |
| *Potentilla fruticosa* | Klinkenberg & Rhodes (1981) | no specimen |
| *Prunus persica* | Cruise (1969) | no specimen |
| *Robinia pseudoacacia* | Klinkenberg & Rhodes (1981) | no specimen |
| *Vicia americana* | Cruise (1969) | no specimen |
| *Linum striatum* | Cruise (1969) | *L. medium* var. *texanum* |
| *Hypericum boreale* | Cruise (1969) | *H. mutilum;* label error |
| *H. canadense* | Cruise (1969) | *H. majus* |
| *H. virginicum* | Cruise (1969) | *Triadenum fraseri* |
| *Opuntia humifusa* | Macoun (1883) | no specimen |
| *Cornus alternifolia* | Snyder (1931) | no specimen |
| *Convolvulus arvensis* | Klinkenberg & Rhodes (1981) | no specimen |
| *Mentha piperita* | Klinkenberg & Rhodes (1981) | no specimen |
| *Pycnanthemum virginianum* | Cruise (1969) | *P. verticillatum* |
| *Physalis subglabrata* | Hurst et al. (1979) | no specimen |
| *Agalinis tenuifolia* | Landon (1960), Cruise (1969) | no specimen |
| *Epifagus virginiana* | Boughner (1898) | no specimen |
| *Utricularia subulata* | Scoggan (1979) | *U. gibba* |
| *Galium palustre* | Cruise (1969) | *G. tinctorium* |
| *Viburnum trilobum* | Snyder (1931) | no specimen |
| *Helenium nudiflorum* | Scoggan (1979) | *H. autumnale* |
| *Helianthus laetiflorus* | Cruise (1969) | *H. strumosus* |
| *Vernonia gigantea* | Cruise (1969), White & Maher (1983) | label error |
| *Solidago missouriensis* | Cruise (1969) | *S. canadensis* |
| *Sonchus uliginosus* | Cruise (1969) | *S. arvensis* |
| *Xanthium chinense* | Cruise (1969) | *X. strumarium* |
| *X. italicum* | Cruise (1969) | *X. strumarium* |

[1]Two species reported by McCracken et al. (1981) from Long Point, *Fraxinus nigra* and *Alnus rugosa,* were from wet woods (Hahn woods) just west of our study area.

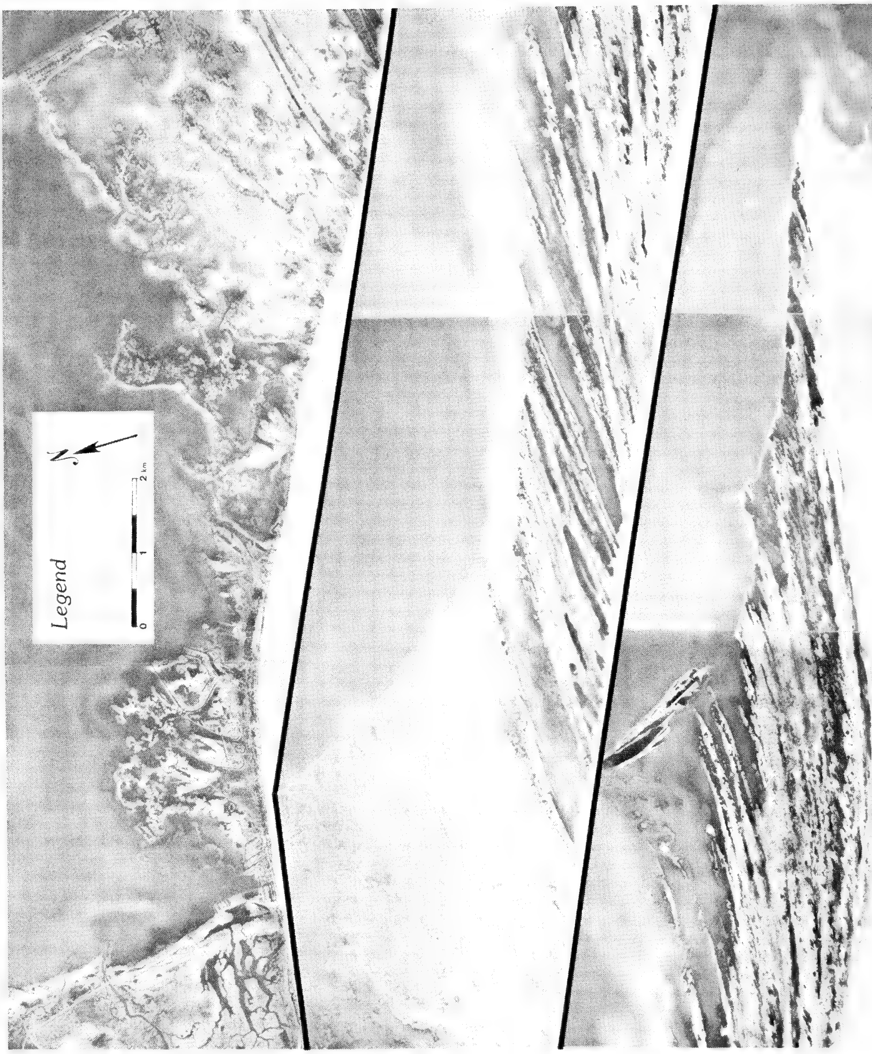


FIGURE 2. Long Point, showing the base with extensive marshes, urbanized areas, and Ryerson's Island (top); the central portion with the parallel ridges (middle); and the tip with a continuation of the parallel ridges and the perpendicular Bluff Island ridges (lower). From the National Air Photo Library, courtesy of Energy, Mines, and Resources Canada.

stops after the Cottonwood savanna stage. Yet older ridges to the west carry the successional stages to the Red Oak-Sugar Maple (*Acer saccharum*) forest (10 in Fig. 3). These successional trends are particularly clearly demonstrated by floristic data for trees. The oldest ridges, Courtright and Squires, have together about 33 species of trees, including a number of deciduous forest species such as *Carpinus caroliniana, Carya ovata, Juglans cinerea,* and *Liriodendron tulipifera.* At Gravelly Bay, the number of tree species is much more limited, with only about 12 present. At the very tip of the Point, only Cottonwood occurs. More complicated and less obvious successional patterns are characteristic of wetland sites as well. Transitions among the vegetation types, frequently occur, especially on the younger areas of the Point. The vegetation of the Point is a complex mosaic due to the irregular topography and the highly variable moisture regimes. A number of important disturbance factors (see under *"Some Important Factors Affecting the Vegetation"*) are also superimposed upon the general successional framework.

Since the Point is generally undulating with parallel ridges and sloughs, there are ponds, meadows, and marshes throughout the forest and savanna areas as well as covering extensive areas toward the base of the Point. Vegetation zonations change abruptly with abrupt changes in elevation. A detailed impression of the vegetation at various parts of the Point is thus more readily obtained through the examination of aerial photographs (see Fig. 2) than even large scale vegetation maps. Our map (Fig. 4) shows only the main regions of the most extensive vegetation types.

## BEACH STRANDS

*Cakile edentula* and locally, *Triplasis purpurea* and *Salsola pestifer*, are frequent above the high water mark in drier sand. However, extensive flat areas of wet sand (Fig. 5) distributed irregularly all along the shores of the Point, and especially along the north beach, have a diverse and characteristic flora, frequently dominated by *Bidens cernuus, Cyperus bipartitus, C. engelmannii, C. odoratus, Juncus alpinoarticulatus, Lycopus europaeus, L. uniflorus,* seedlings of *Populus deltoides,* and *Scirpus pungens*. Other important species include *Cyperus diandrus, C. erythrorhizos, C. flavescens, C. strigosus, Echinochloa muricata, E. walteri, Eleocharis acicularis, E. caribaea, E. olivacea, Juncus nodosus, Leersia oryzoides, Panicum capillare, P. tuckermanii, Polygonum lapathifolium, P. punctatum, Rorippa palustris, Scirpus smithii, Scutellaria galericulata,* and *S. lateriflora*. Essentially identical vegetation to these beach strands is also found inland on bare sand around the youngest ponds near the tip of the Point. Strand vegetation is very variable and fluctuates widely in species composition and density from year to year. Some less common strand species, such as *Eleocharis caribaea, Fimbristylis autumnalis,* and *Panicum tuckermanii,* are rare or not in evidence at all during years of high Great Lakes water levels.

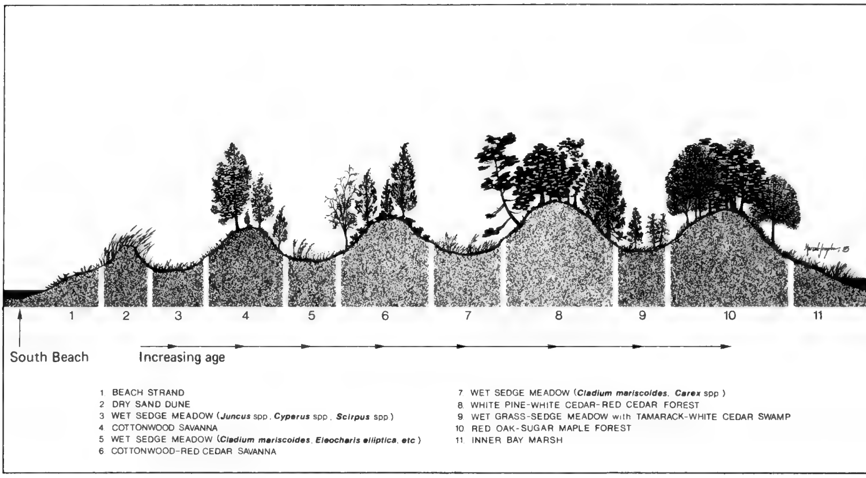


FIGURE 3. Diagramatic representation of vegetation on ridges of increasing age from the south to the north side of the outer portion of Long Point (after Catling & Reznicek 1981).

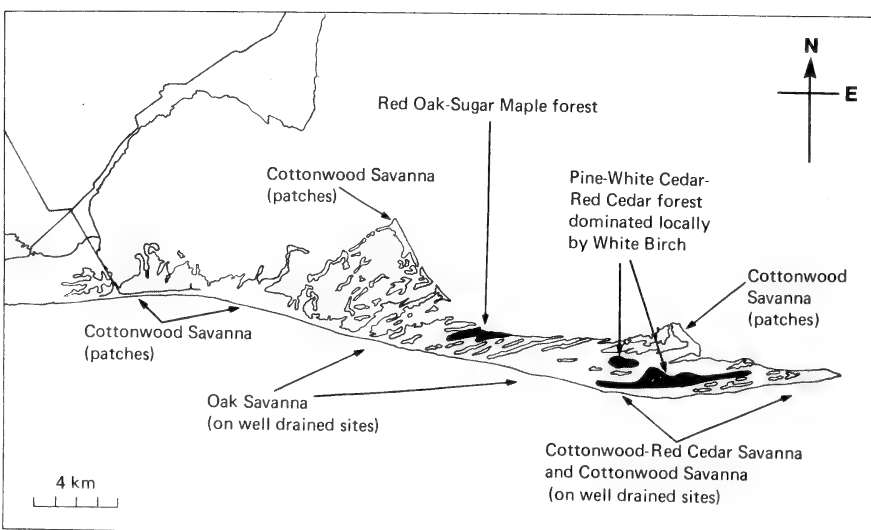


FIGURE 4. Long Point showing major regions of savanna and forest.

FIGURE 5. View across recently formed strands along the north beach, and adjacent ponds near the tip of Long Point. Young Cottonwoods (*Populus deltoides*) are in the background. Sept. 21, 1979.

FIGURE 6. Cottonwood-Red Cedar (*Populus deltoides-Juniperus virginiana*) savanna on a dune ridge and adjacent interdunal wet sedge meadows southeast of Gravelly Bay. The dead Cottonwoods are characteristic of this older savanna. Sept. 21, 1979. Previously published as the cover photo for Michigan Bot. Vol. 21(1), 1982.

## WET MEADOWS

### *a. Sedge Meadows*

The extensive wet sedge meadows are perhaps the most variable and complex plant community on Long Point. These meadows (Figs. 6 & 7) occur mainly in the Cottonwood-Red Cedar savanna area (i.e., the outer 10 km of the Point) and near the base of the Point on the north side from near the causeway to Long Point Provincial Park (where this unusual plant community has been largely replaced by picnic and camping areas).

This variation is due not only to succession, but also to cyclic changes in Great Lakes water levels. In the younger meadows near the tip, on sand substrate, composition can change markedly from year to year with changes in water levels. Even in the older meadows, the width and composition of vegetation zones are dependent upon water level. The brief sketch presented herein thus offers only a general introduction to this rich and fascinating (and much too little studied) community that contains many of Long Point's rare or interesting plant species. The discussion is oriented towards the two major factors influencing the composition of Long Point sedge meadows: age and moisture.

The youngest meadows on the Point have a flora similar to that of the beach strands, often low vegetation cover, and a pure sand substrate. Somewhat older meadows, also on nearly pure sand, are dominated by species such as *Agalinis paupercula, Eleocharis elliptica, E. quinqueflora, Equisetum variegatum, Helenium autumnale, Juncus alpinoarticulatus, J. balticus, Linum medium, Parnassia glauca, Rhynchospora capillacea, Scleria verticillata, Scirpus pungens,* and *Solidago ptarmicoides.* Meadows older still, with some organic matter and marl accumulation, have many of the same dominants but also include prominant representation of species such as *Andropogon scoparius, Aristida necopina, Aster dumosus, Calamagrostis canadensis, Carex crawei, Castilleja coccinea, Cladium mariscoides, Eupatorium perfoliatum, Hypericum kalmianum, Scirpus acutus, Spiranthes cernua, Sporobolus vaginiflorus, Thelypteris palustris,* and *Tofieldia glutinosa.*

Variation in composition with moisture is difficult to define in a community where fluctuating water levels play such a major role. The very wettest sites, in depressions with water to 3 dm deep in the older meadows near Gravelly Bay, are relatively species-poor and dominated by *Cladium mariscoides, Eleocharis quadrangulata, Potamogeton gramineus, Proserpinaca palustris, Scirpus acutus,* and, visible only when flowering during low-water years, *Utricularia resupinata.* The driest sites grade into dry dunes and are dominated by species such as *Andropogon scoparius, Aristida necopina, Aster dumosus, Dichanthelium implicatum, Fragaria virginiana, Liatris cylindracea, Panicum virgatum, Solidago nemoralis, S. ptarmicoides, Sorghastrum nutans,* and *Sporobolus vaginiflorus.* Between these two extremes the meadows are dominated by various combinations of the

the species noted in the paragraph above, depending on both the age of the meadow and the water level.

The meadows near the base have more organic material and surficial encrustations of marl in some areas, and thus appear to be older than those near the tip. *Calamagrostis canadensis* and *Solidago ohioensis* are dominants or co-dominants while *Solidago ohioensis* is lacking in the meadows near the tip of the Point. *Cladium mariscoides* as well as shrubs, especially *Cornus* spp., are also much more widespread in the basal meadows, and communities and zonations are more difficult to discern. Sandy, open-ground communities, such as those involving *Aristida necopina* or *Eleocharis quinqueflora,* are rare at the base of the Point.

*b. Grass Meadows*

*Calamagrostis canadensis* is dominant in many wet meadows and shallow marshlands on the Point (e.g., between the older ridges west of Gravelly Bay). It occurs as a dominant with only a very few other species such as *Thelypteris palustris* being important, and is characterized by a considerable build-up of organic material.

Observations relating to age and amount of organic material suggest the following direction in the succession of wet meadows. Wet strand vegetation is followed by the interdunal meadows outlined above, this in turn followed by the extension of *Calamagrostis canadensis, Cladium mariscoides,* and *Thelypteris palustris* over the lower areas, and the gradual development of Tamarack (*Larix laricina*) and White Cedar forest on the upper levels. Finally, only wet, open meadows remain, dominated primarily by *Calamagrostis canadensis* and with substantial litter and organic matter accumulation.

While this is an interesting hypothesis for which there is circumstantial evidence, the situation is actually more complex. Zonation patterns in the more recently formed wet hollows are influenced not only by elevation and overall moisture content, but also by the duration and periodicity of wetness or inundation and by dispersal events, as well as by variation in other edaphic factors.

## WETLANDS AND AQUATIC COMMUNITIES

Wetlands and aquatic communities are rich and diverse on the Point. Except near the base, extensive, monotonous areas dominated by *Typha* to the exclusion of most other species are not characteristic of Long Point. Nevertheless, these communities have been relatively little-studied from a floristic or vegetational viewpoint. The comments below do little more than give a general picture and highlight a few areas.

Areas of standing water to 1 m deep between the outer ridges, such as Anderson Pond, have emergents including *Eleocharis quadrangulata, Pontederia cordata, Scirpus acutus,* and *S. pungens* as well as various submerged and floating-leaved aquatics including *Myriophyllum spicatum,*

*Najas flexilis, N. guadalupensis, Potamogeton amplifolius, P. gramineus, P. pectinatus, P. zosteriformis, Polygonum amphibium,* and *Vallisneria americana.*

After a long period of isolation from the lake, the water in these sloughs becomes more neutral and various species characteristic of neutral and acid waters have become established. An isolated pond between ridges less than 100 m from Anderson Pond near the north side of the Point is dominated by one such species, *Brasenia schreberi.* A long slough between ridges on the south side of the Point between Gravelly Bay and the Little Creek Ridges was surrounded by hummocks and quaking mats comprised principally of *Carex aquatilis, Thelypteris palustris,* and *Typha latifolia* with *Drosera rotundifolia, Lycopus uniflorus, Potentilla palustris, Triadenum fraseri,* and *Viola macloskeyi* on the mats and hummocks. *Scirpus subterminalis* formed dense beds in shallow water (to 1 m) with *Myriophyllum verticillatum, Najas flexilis, Nuphar variegata, Nymphaea odorata, Polygonum amphibium, Utricularia intermedia,* and *U. vulgaris.* Of the species listed above, *Brasenia schreberi, Drosera rotundifolia,* and *Scirpus subterminalis* are rare in extreme southern Ontario and usually associated with soft or nutrient-poor water. Very locally, especially near the Little Creek Ridges, these floating mats may also have an important component of *Sphagnum,* with *S. capillifolium* (Ehrh.) Hedwig and *S. russowii* Warnst. being the most important species. Other species found on the Point primarily in floating mats are *Carex chordorrhiza, C. limosa, Epilobium strictum, Eriophorum gracile, Menyanthes trifoliata, Rhynchospora alba, Salix pedicellaris,* and *Utricularia minor.*

The Cedar Creek slough is deep and wide and continues from one side of the Point obliquely to the other. It is probably continuous with the outer bay or with Lake Erie periodically during high water and storms. The dominant emergent in Cedar Creek is *Zizania palustris,* with some *Sagittaria latifolia* and *Scirpus acutus.* The water here is turbid and there are few submerged aquatics. The turbid water, scarcity of submerged aquatics, and domination by *Zizania palustris* makes Cedar Creek conspicuously different from the sloughs to the east and west.

Water 0.5 to 1 m deep in the sloughs between the older ridges near Squires Ridge is dominated by dense growths of *Cephalanthus occidentalis* and *Decodon verticillatus* (Fig. 8) with a minor component of *Bidens coronatus, Boehmeria cylindrica, Calamagrostis canadensis, Carex comosa, C. lacustris, C. pseudo-cyperus, C. stricta, Lycopus uniflorus, Pilea fontana, Scutellaria galericulata, Solanum dulcamara,* and *Thelypteris palustris. Lemna minor* and *Spirodela polyrhiza* float on the surface of these sloughs. Open water is variously dominated by *Ceratophyllum demersum, Elodea canadensis, Myriophyllum verticillatum, Potamogeton natans,* and the algae *Nitella* and *Chara,* with *Dulichium arundinaceum, Nuphar variegata, Polygonum amphibium, Sparganium chlorocarpum,* and *Utricularia vulgaris* abundant locally.

The marshes contiguous with the outer bay along the north beach are variously dominated by *Calamagrostis canadensis, Carex aquatilis, C.*

FIGURE 7. Rich interdunal sedge meadow community southeast of Gravelly Bay. Note the zonations from water-filled depressions to the more or less bare sand at the lower edge of the Cottonwood-Red Cedar (*Populus deltoides-Juniperus virginiana*) savanna on the dune ridges. Sept. 21, 1979.

FIGURE 8. A long pond surrounded by Water Willow (*Decodon verticillatus*) near Squires Ridge. Sept. 20, 1979.

*stricta, Glyceria grandis, Phragmites australis, Sagittaria latifolia, Scirpus acutus, S. validus, Sparganium eurycarpum, Typha ×glauca,* and *T. latifolia,* with large stands of *Pontederia cordata* locally in deeper water. *Carex stricta* sometimes forms dense stands in shallow water up to 2 to 3 dm deep (Fig. 9). These marshes grade into sedge and grass meadows in some sites.

Marshes in the inner bay, especially those west of Ryerson's Island, are composed primarily of dense stands of *Typha ×glauca* (see background of Fig. 26) with relatively little diversity, except in occasional openings and on the edges. *Typha ×glauca* is also important in marshes at the base of the Point, adjacent to the mainland, but those marshes also have a significant component of *Calamagrostis canadensis, Carex aquatilis, C. stricta, Phragmites australis,* and, especially around ponds, *Decodon verticillatus. Sagittaria latifolia* also is frequent locally. Frequent open water areas in the inner bay marshes and the marshes near the base are dominated by *Ceratophyllum demersum, Elodea canadensis, Heteranthera dubia, Myriophyllum heterophyllum, M. verticillatum, Nuphar variegata, Pontederia cordata,* and *Potamogeton pectinatus.*

## DRY SAND DUNES

The areas of accumulating sand (Fig. 10), which are well-developed at the eastern end of the Point on the south shore, are dominated by *Ammophila breviligulata* with *Corispermum hyssopifolium, Lathyrus japonicus,* and *Salsola pestifer.* Where sand is accumulating to a lesser degree, *Andropogon scoparius, Panicum virgatum,* and *Sporobolus cryptandrus* may also be important in the total cover. Other characteristic species of this community include *Arabis lyrata, Artemisia campestris, Asclepias syriaca, Cycloloma atriplicifolia, Elymus canadensis, Euphorbia polygonifolia, Lithospermum caroliniense, Melilotus alba, Poa compressa, Polanisia dodecandra,* and *Triplasis purpurea.* Locally, the mosses *Tortella tortuosa* (Hedwig) Limpr. and *Tortula ruralis* (Hedwig) Gartn. are conspicuous. This type of vegetation extends from the tip westward 13 km along the south shore, occurring at numerous points elsewhere along the south shore and sporadically along the north shore. It may also be seen in some of the older ridges where blowouts have developed (see cover photo). Near the base, in Long Point Provincial Park, more disturbed dunes may also be seen, with a higher shrub and vine componenent, including *Prunus pumila, Rosa blanda, Toxicodendron radicans,* and *Vitis riparia.*

## COTTONWOOD-RED CEDAR SAVANNA

This distinctive community (Fig. 6) occurs on dry sites on the outer 10 km of the Point (i.e., from west of Bluff Point almost to the tip). From the western end (where it is confined to a few ridges on the south shore) toward the east, the zone gradually becomes wider until about 1.5 to 3 km from the tip it extends across the Point (Fig. 4). There is a relatively large area of this

FIGURE 9. Sedge (*Carex stricta*) marsh in shallow water to 2 dm deep along the south shore of Duncan's Pond near the north beach close to the tip. Red Cedar (*Juniperus virginiana*) savanna, with a few old Cottonwood (*Populus deltoides*) still living, in the background. June 14, 1980.

FIGURE 10. Marram Grass (*Ammophila breviligulata*) rapidly accumulating sand on the lee of an eroding dune on the south side of Long Point at Cedar Creek. The extensive Wild-Rice (*Zizania palustris*) marsh at Cedar Creek is visible in the background. Sept. 20, 1979.

habitat near the tip of the Point, east of Gravelly Bay, representing one of the largest areas of Cottonwood-Red Cedar savanna in Canada (small areas of similar communities may be seen in Pinery Provincial Park, Point Pelee National Park, and Pelee Island).

The community is characterized by scattered Cottonwood and Red Cedar, the latter appearing after the former is already well-developed. Grasses are dominant, including *Ammophila breviligulata, Andropogon scoparius, Dichanthelium acuminatum, Elymus canadensis, Panicum virgatum, Poa compressa, Sorghastrum nutans,* and *Sporobolus cryptandrus,* as well as various herbs including *Arabis lyrata, Asclepias syriaca, Liatris cylindracea, Lithospermum caroliniense, Melilotus alba,* and *Solidago nemoralis. Liatris cylindracea* occurs at the bases of slopes surrounding the numerous wet meadows and ponds. *Arctostaphylos uva-ursi* and *Juniperus communis* are established on some of the older ridges. The youngest stages of this community, near the south beach, have small Cottonwood trees on young dune ridges, with an understory basically identical to that of the open dunes. Red Cedar is present only as small seedlings. Conversely, the oldest stages of this community, near the north beach, have only Red Cedar; virtually all of the Cottonwoods have died (see Fig. 9). In a few small areas, especially near the base of the Point and on Ryerson's and Bluff Islands, mature Cottonwoods form savanna or open forest without Red Cedar.

## WHITE PINE-WHITE CEDAR-RED CEDAR FOREST

Although there are no extensive areas of this community on Long Point, it occurs on many ridges in the Gravelly Bay region (Fig. 4). *Juniperus virginiana* and *J. communis* with young *Pinus strobus* are characteristic of the early stages, with mature *Pinus strobus* and *Thuja occidentalis,* and some White Birch (*Betula papyrifera*) and *Quercus rubra* in the late stages (Fig. 11). Locally, *Betula papyrifera* dominates small areas. In most areas, this is an open forest with a "weedy" herb layer comprised of *Poa compressa* with *Asclepias syriaca, Calamagrostis canadensis, Cynoglossum officinale, Oryzopsis racemosa, Physalis heterophylla, Poa pratensis, Rubus strigosus,* and *Verbena urticifolia.* Some open ridge-tops have the native *Festuca saximontana, Lithospermum caroliniense, Oryzopsis asperifolia,* and *Smilacina stellata.* The openness in many areas appears to be the result of lack of tree reproduction, as saplings of all species are rare. On one ridge there are large openings where White Pines have fallen, but only the weedy herbs described above are growing in the open spaces.

In small isolated areas, the forest is closed and in these areas the herb layer contains *Carex eburnea, Hackelia virginiana, Linnaea borealis, Melampyrum lineare, Moehringia lateriflora, Symphoricarpos alba,* and *Trientalis borealis.* All of these species may persist for some time in a more open forest resulting from the falling of trees, and therefore may be found in communities with the species characteristic of more open sites.

## TAMARACK-WHITE CEDAR SWAMP

Only small fragments of this vegetation type now exist intact. Extensive flooding from recent high Lake Erie water levels has killed or badly injured most of the trees, so that now it is a rather open swampland. It is likely that the understory flora was interesting and distinctive but, in many areas, there are now extensive open meadows of *Calamagrostis canadensis* beneath a mature, but dead, Tamarack-White Cedar canopy. Relatively dense stands of young Tamarack (1–5 m tall) are, however, developing locally. Other species characteristic of this now open swampland include: *Boehmeria cylindrica, Carex aquatilis, C. lacustris, C. stricta, Cirsium muticum, Glyceria striata, Impatiens capensis, Lathyrus palustris, Lycopus uniflorus, Mentha arvensis, Scutellaria galericulata, Solidago canadensis,* and *Thelypteris palustris.* White Cedar mixes with White Pine and White Birch at the base of slopes and hence, this community of wet sites intermingles with the preceding community which is characteristic of drier sites.

## RED OAK-SUGAR MAPLE FOREST

This forest (Fig. 12), heavily dominated by Red Oak and Sugar Maple with minor components of *Fraxinus americana, Acer rubrum,* and scattered other trees, is virtually confined to a small area at the northern end of Squires Ridge (Fig. 4). Saplings are entirely lacking, but seedlings of *Acer saccharum* are abundant. Various grasses and sedges are locally abundant including *Bromus latiglumis, Calamagrostis canadensis, Carex artitecta, C. rosea, Elymus hystrix, E. villosus, Festuca obtusa, Muhlenbergia schreberi, M. tenuiflora,* and *Poa pratensis.* Weedy species, such as *Asclepias syriaca, Leonurus cardiaca, Parietaria pensylvanica,* and *Urtica dioica* are frequent. Ferns, including *Athyrium filix-femina, Cystopteris tenuis, Dryopteris carthusiana,* and *Polystichum acrostichoides,* occur locally on steep north-facing slopes. Wet, open depressions are dominated by *Boehmeria cylindrica, Calamagrostis canadensis, Leersia oryzoides,* and *Thelypteris palustris,* with *Bidens cernuus* on the mud around the frequent forest ponds. Some more open glades are dominated by *Carex pensylvanica* and *Danthonia spicata.*

The absence of saplings gives the forest a very open aspect and the local abundance of a number of unusual grasses and sedges also contributes to its peculiar appearance. Only locally is the tree canopy truly dense and forest-like.

## OAK SAVANNA

Many of the ridges between Courtright Ridge and Bluff Point (Fig. 4) are covered with Oak savanna (Fig. 13). This is essentially an open grassland with scattered large trees occurring at widely varying densities. There are virtually no saplings, and tree seedlings are very scarce. The dominant

FIGURE 11. Open stand of White Pine (*Pinus strobus*) with some White Cedar (*Thuja occidentalis*) and White Birch (*Betula papyrifera*) near Gravelly Bay. The grassy and weedy understory is conspicuous. May 25, 1980.

FIGURE 12. Red Oak-Sugar Maple (*Quercus rubra-Acer saccharum*) forest completely lacking a normal forest understory. North end of Squires Ridge. June 16, 1980.

tree is *Quercus rubra,* with varying amounts of *Acer rubrum, Celtis occidentalis, Fraxinus americana, Ostrya virginiana, Prunus serotina, Quercus alba, Q. muehlenbergii, Sassafras albidum,* and *Tilia americana.* To the east, *Betula papyrifera, Pinus strobus,* and *Thuja occidentalis* also occur with *Quercus rubra.* In a few areas, notably Ryerson's Island, *Quercus macrocarpa* may be important or even dominant in the Oak savanna, along with species like *Celtis occidentalis* and *Tilia americana.* Except for the Ryerson's Island savannas, which have a shrub understory of *Cornus drummondii* and *Prunus virginiana,* there are virtually no shrubs or thickets in this community. The very few individuals of generally shrubby species that are present (*Amelanchier arborea, Prunus virginiana,* and *Sambucus canadensis*) are distinctly tree-like (see Fig. 16). The only true shrub present is the fiercely thorny alien *Rosa rubiginosa,* and the general aspect is that of an arboretum.

The dominant grasses in the Oak savanna are *Calamagrostis canadensis, Panicum virgatum, Poa compressa, P. pratensis,* and *Sporobolus cryptandrus, Poa compressa* and *Sporobolus* being characteristic of the drier sites. Herbs are secondary to grasses in cover and include *Anaphalis margaritacea, Arabis glabra, Asclepias syriaca, Cerastium fontanum, Conyza canadensis, Gnaphalium obtusifolium, Lepidium campestre, Physalis heterophylla, Pteridium aquilinum, Rumex acetosella, Solidago canadensis,* and *Verbascum thapsus. Asclepias syriaca* and *Pteridium aquilinum* can be important dominants locally.

*Dryopteris marginalis* and patches of *Carex eburnea* occur with *Calamagrostis canadensis* and *Poa pratensis* in the open at the bases of north-facing slopes, suggesting a formerly more densely forested condition. The *Carex eburnea* particularly suggests the former presence of its frequent associate *Thuja occidentalis.* The trees scattered through the Oak savanna, invariably standing alone, include many typically forest species. These trees often do not appear open grown (Fig. 14), but rather have long, clear boles and are evidently relics.

The presence of a weedy "old-field" herbaceous flora in the Oak savanna areas instead of a well-developed exclusively native savanna flora, which would include such characteristic genera as *Andropogon, Desmodium, Lespedezea,* and *Liatris,* also suggests that the habitat is of recent origin. Fire, logging, and heavy deer browsing are probably responsible for the development and maintenance of the Oak savanna.

A more characteristically native savanna occurs in isolated patches on Squires Ridge where open glades are dominated by *Carex pensylvanica* and *Danthonia spicata* with *Antennaria neodioica, A. parlinii, Carex artitecta, C. muhlenbergii, C. nigromarginata, C. rugosperma, Dichanthelium oligosanthes, D. latifolium, D. linearifolium, Poa compressa,* and dryland mosses such as *Dicranum scoparium* Hedw., *Leucobryum albidum* (Brid. *ex* P.-Beauv.) Lindb., and *Polytrichum ohioense* Ren. & Card. Unlike the generally calcareous or more or less neutral character of most of Long Point's habitats, these small areas of native savanna have quite acid soils with a surface pH as low as 4.6. These areas are isolated forest glades or

FIGURE 13. Oak savanna near the southwest end of Courtright Ridge. Tree reproduction and a shrub layer are totally lacking. Sept. 20, 1979.

FIGURE 14. An isolated Red Oak (*Quercus rubra*) in Oak savanna near the west end of the Little Creek Ridges showing a long, clear trunk suggesting a forest origin. June 15, 1980.

TABLE 4. Weedy species characteristic of areas disturbed through human activity and found primarily along roadsides and about buildings on Long Point. Species are in the same order as in the *"Annotated List of Vascular Plants."*

| | |
|---|---|
| *Agrostis gigantea* | *Capsella bursa-pastoris* |
| *A. stolonifera* | *Diplotaxis tenuifolia* |
| *Bromus tectorum* | *Erucastrum gallicum* |
| *Digitaria ischaemum* | *Erysimum cheiranthoides* |
| *D. sanguinalis* | *Potentilla argentea* |
| *Eragrostis pectinacea* | *Medicago lupulina* |
| *Festuca pratensis* | *Melilotus alba* |
| *Panicum dichotomiflorum* | *Trifolium pratense* |
| *Phleum pratense* | *T. repens* |
| *Poa annua* | *Euphorbia maculata* |
| *Setaria glauca* | *Daucus carota* |
| *S. viridis* | *Glechoma hederacea* |
| *Polygonum arenastrum* | *Plantago lanceolata* |
| *Chenopodium album* | *P. major* |
| *Amaranthus retroflexus* | *Ambrosia artemisiifolia* |
| *Portulaca oleracea* | *Arctium minus* |
| *Cerastium fontanum* | *Cichorium intybus* |
| *Silene latifolia* | *Cirsium arvense* |
| *Ranunculus acris* | *Lactuca serriola* |
| *Barbarea vulgaris* | *Sonchus arvensis* |

ridge crests surrounded by the more "weedy" cover characteristic of most of the Oak savanna or Red Oak-Sugar Maple forest (Reznicek & Catling 1982).

## WEEDY HABITATS

A characteristic group of plants associated with human disturbance occurs along roadsides and surrounding buildings. This element is well-developed along the causeway and about the cottage community at the base of the Point. Some characteristic species are listed in Table 4. Some introduced weedy species also appear around cottages and cabins and along trails and old roads further out on the Point (e.g., *Bromus tectorum* and *Saponaria officinalis*). Such species may have persisted since the late 1860's when there were garden plots, peach orchards, and vineyards at the north end of Courtright Ridge and some of the other ridges (Barrett 1981, McKeating 1983).

## *5. Some Important Factors Affecting the Vegetation*

It is now widely recognized that the flora of the deciduous forest ("Carolinian") zone of southwestern Ontario is unusual compared to the adjacent regions to the north (Soper 1962), but the flora and the composition of the vegetation on Long Point are also unusual with respect to the immediately adjacent mainland. Some of the reasons for this are self-evident. Plants that are found only on shoreline sand dunes are not likely to

be found inland. However, the explanations for the occurrence of other unusual groups of species and for certain characteristics of the vegetation are less obvious. In addition to the factors which normally influence vegetation development, such as the age and character of the substrate, there are a number of other important factors influencing the vegetation of the Point.

## LOGGING AND FIRE

One of the most obvious unusual characteristics of Long Point is the general absence of broad-leaved shrubs and tree saplings and the rather open and park-like appearance of the landscape (Figs. 13 & 14). The extent to which this openness is a natural phenomenon has been a point of debate (McKeating 1980).

Long Point had been extensively logged by the late 1860s, and the records suggest that most of the tree species now present were being cut at that time. As early as 1869, Courtright Ridge, which was almost certainly largely forested in presettlement times, was described as "good pasture," suggesting that logging had already created open forest and savanna by that time. Between the early 1920s and 1951, commercial logging operations resulted in the cutting of Maples, Red and White Cedar, Red Oak, and White Pine throughout the area between Courtright Ridge and Gravelly Bay (McKeating 1983).

Dead wood, brush, and wind-thrown trees remaining from the lumbering operations contributed fuel to a series of fires, the earliest of which was recorded in 1881 (Heffernan & Ralph 1978). The last major fire outside of the marshes occurred in 1962 in the area between Squires Ridge and Gravelly Bay. Minor fires and local grass fires probably occur frequently, and evidence of fire is everywhere apparent in fire scars on the trees (Fig. 15). While fires are a natural phenomenon in many extensive areas of natural vegetation, the present vegetation on the Point is mostly not of the type that is associated with a long history of periodic natural fires.

The alteration of the vegetation of the Point as a result of logging and fire is very substantial, and there can be little doubt that the open forests and savannas that exist today resulted in part from these factors (excluding the Cottonwood and Cottonwood-Red Cedar savannas, which represent a successional phase).

## BROWSING BY DEER

Excessive browsing by white-tailed deer, obvious throughout the Point, has contributed substantially to the lack of any redevelopment of forest cover in the Oak savanna areas, Red Oak-Sugar Maple forest and White Pine-White Cedar-Red Cedar forest. The Long Point deer herd is presently about 500 (McCullough & Robinson 1988). These 500 deer are essentially confined to the area between Courtright Ridge and the tip, an area about 22

km long, averaging perhaps 1 km wide, with a substantial portion of open water.

If the pressure of browsing is not substantially reduced, the woody vegetation of the Point will be further diminished with the exception of thorny or less palatable species like *Juniperus communis, J. virginiana,* and *Rosa rubiginosa.* The absence of shrubs like *Prunus pumila* and various *Salix* spp. over large parts of the Point is probably attributable to the large deer population. The scarcity and tree-like appearance of the few shrubs present suggests that they are rare survivors from a time when shrubs were much more frequent because they were too tall to be browsed to death (Fig. 16). In fact, although this flora does contain numerous shrubs, records for many of them come from either developed areas near the base of the Point or from Ryerson's Island, where deer browsing is much less; or the records are based on old collections. If deer populations remain too high, Long Point will become even more open, as mature trees die and are not replaced. The large deer population also influences the herbaceous flora, but this is less obvious. While the overall effect of a large deer population is negative, it probably has contributed to an increase in some generally uncommon herbaceous species, especially grasses and sedges, by reducing competition from shrubs and broad-leaved herbs. Since 1980 the Canadian Wildlife Service has studied the effects of deer browsing using exclosure and control plots (McCullough & Robinson 1988).

## CLIMATE AND MICROCLIMATE

Climate and microclimate are generally important in accounting for occurrences of vascular plants, but on Long Point these factors may have an exceptionally strong influence. The large number of boreal species on the Point (see under *"Phytogeography"*) especially as compared with other north shore peninsulas (see under *"Comparison of the Floras of Long Point, . . ."*), is probably attributable to both climatic and microclimatic influences. Being surrounded by water, the Point thus has a moderate climate. This is strikingly demonstrated in the data graphically presented by McCracken et al. (1981). Despite a relatively long frost-free period (compared to mainland sites), the Point is usually cooler than the mainland during periods of warm weather. Plant growth is undoubtedly hindered in the spring when the surrounding lake water is cold. The eastern basin of Lake Erie is the deepest part and may require relatively more time to heat up in the spring and early summer. It is also possible that the prevailing westerly winds push melting ice into the eastern end of Lake Erie which would also have a cooling effect in the spring. In terms of microclimate, snow accumulation at the base of wooded ridges, and especially on the north slopes, may also contribute to locally cool conditions early in the year. Finally the steep, north-facing and wooded slopes of the ridges, which are largely protected from the warming effect of the sun, probably also contribute to producing a microclimate where species of primarily northern affin-

FIGURE 15. Tulip Tree (*Liriodendron tulipifera*) with a prominent fire scar in Oak savanna on Squires Ridge. May 25, 1980.

FIGURE 16. An unusually tree-like form of Elderberry (*Sambucus canadensis*) in open Oak savanna on a low ridge. The Elderberry trunk was 13 cm in diameter at breast height. This unusual form was probably caused by continuous browsing by deer. Near the east end of the Little Creek Ridges. A.A. Reznicek standing on the left. May 24, 1980.

ity can exist. Many of these species are rare and confined to cold bogs and swamps in the deciduous forest ("Carolinian") zone of the mainland to the north.

Although floristic composition suggests that the relative coolness of the Point is a significant influence, the long frost-free period and moderation during cold periods are also important factors. They may account for the occurrence on the Point of certain southern species which reach their northern limit in the deciduous forest ("Carolinian") zone of southern

Ontario. There is, in fact, mingling of northern and southern elements. Although the presence of these different elements is probably explained by a variety of factors, such as more widespread occurrence of boreal species in the past and differing migration routes and rates, they are nevertheless maintained by the climate and microclimates that exist today.

PHYSICAL DISTURBANCES

An understanding of the processes that led to the creation of Long Point, and continue to change its shape and size, is not critical to an appreciation of the present flora with two exceptions. First, the erosion of old land surfaces and creation of new ones is a continual process, and second, the westernmost ridges, like Courtright Ridge, are older than the ridges to the east. The erosional and depositional processes have been reviewed in detail by Bradstreet (1977) and Davidson-Arnott and Stewart (1987).

On some parts of the Point, erosion is precipitating forest and savanna into the Lake Erie waves. This has alarmed some observers. Erosion and deposition are natural processes, although erosion may predominate at times as a result of a natural slowing of land build-up near the tip (due to deposition in deeper water), man-made changes elsewhere along the Lake Erie shoreline (which may reduce deposition), or simply high Lake Erie water levels. In any event, there is continual creation of new, bare sand habitats on Long Point.

Water levels in Lake Erie fluctuate from year to year, within a year, and sometimes over a period of a day when the prevailing west winds push water into the eastern basin. These fluctuations definitely influence the composition of the vegetation. Fluctuating water levels are important in maintaining both certain unusual species and high floristic diversity (Keddy & Reznicek 1985). However, record extremes of the cycles can also have devastating effects on certain vegetation types. For example, Tamarack-White Cedar swamps cover substantial areas near Gravelly Bay, but most of the trees are now dead as a result of recent record high water levels. What were formerly closed swamps are now mostly wet, grass meadows. This essentially devastated forest habitat may have included plant species which are now extirpated on the Point, as it apparently had received little attention from earlier botanists.

### *6. Phytogeography*

The flora of any diverse area in the Great Lakes region is made up of species with varying geographical affinities. Long Point is no exception. While it is easy to speak of floristic affinities in vague generalities, with this discussion we present maps and species lists (on which the totals in Fig. 23 were based). Specifics are, however, much harder to pin down, and the inclusion of a particular species on a list can be arbitrary. How many stations are allowed in Ohio or West Virginia, for example, before a species can no longer be considered of "northern affinity?" Thus the discussion

following does not attempt to categorize every species known from the Point as to geographic affinity, but rather briefly highlights the major elements that are important in determining the character of the Long Point flora.

## NORTHERN SPECIES

The floristic group that contributes most to Long Point's distinctive character is the northern, or boreal, element; that group of species characteristic of the coniferous forest zone of northern North America. In many cases, these species are also circumboreal. Typical distributions for this element are shown by *Carex chordorrhiza* (Fig. 17) and *Linnaea borealis* (Fig. 18). A listing of northern species in the Long Point flora is given in Table 5.

One interesting, if ominous, fact is that many northern species on the Point are known only from older (pre-1979) collections and were not seen during our survey. This includes 13% of the species listed in Table 5 (asterisked), including such species as *Cornus canadensis* and *Pyrola chlorantha*. By contrast, only *Justicia americana* and *Pycnanthemum verticillatum* among southern species were neither seen by us nor represented by post-1979 collections; *Justicia,* however, was collected in 1977.

## SOUTHERN SPECIES

Long Point is well within the deciduous forest ("Carolinian") zone of Ontario, thus it naturally has a strong component of southern species that reach their northern limits in extreme southern Ontario. Figures 19 and 20 show, repectively, the Great Lakes region distributions of *Carex nigromarginata,* a southern species found in Canada only at Long Point, and *Liriodendron tulipifera,* a more widespread southern species. Table 6 lists southern species known from Long Point. These species are marked according to whether they are forest species (F); prairie, savanna, or dune species (P); or wetland species (W) to provide the comparisons given in Fig. 23.

## GREAT LAKES SHORELINE SPECIES

Since Long Point has been built by sand deposition extending out into Lake Erie, the Great Lakes shoreline element is prominent both in number of species and ecological importance. Table 7 lists Great Lakes shoreline species found on Long Point. While most of these species are virtually confined to the immediate lakeshores, some do have a few inland stations. Fig. 21 maps the Great Lakes region distribution of *Carex crawei*, which has about 70% of its occurrences on the shores of the Great Lakes, with most of the remaining stations inland, but close to the lakeshores. Maps for most of the other Great Lakes shoreline species in Table 7 are given by Guire and Voss (1963), including such species as *Ammophila breviligulata* and *Cakile*

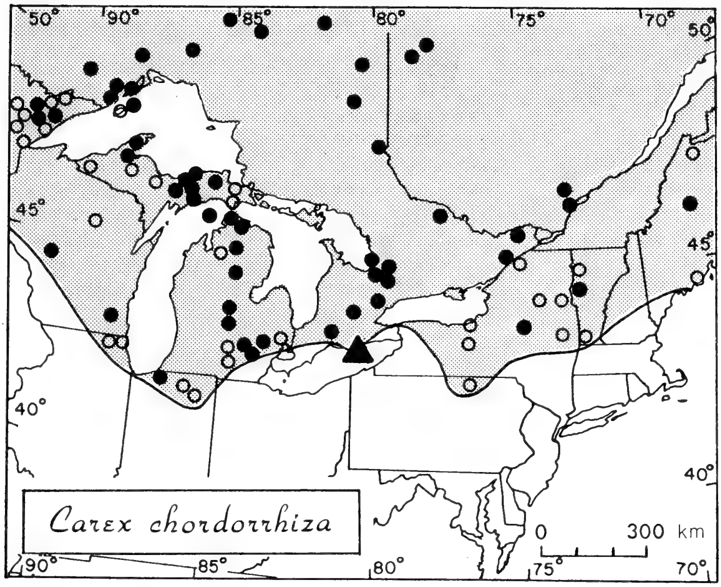


FIGURE 17. Distribution of the sedge *Carex chordorrhiza* in the Great Lakes region based on specimens in CAN, DAO, MICH, and TRT. Open circles are literature records from Deam (1940), House (1924), Lakela (1965), Mohlenbrock and Ladd (1978), Seymour (1960, 1982), Voss (1972), and Wherry et al. (1979).

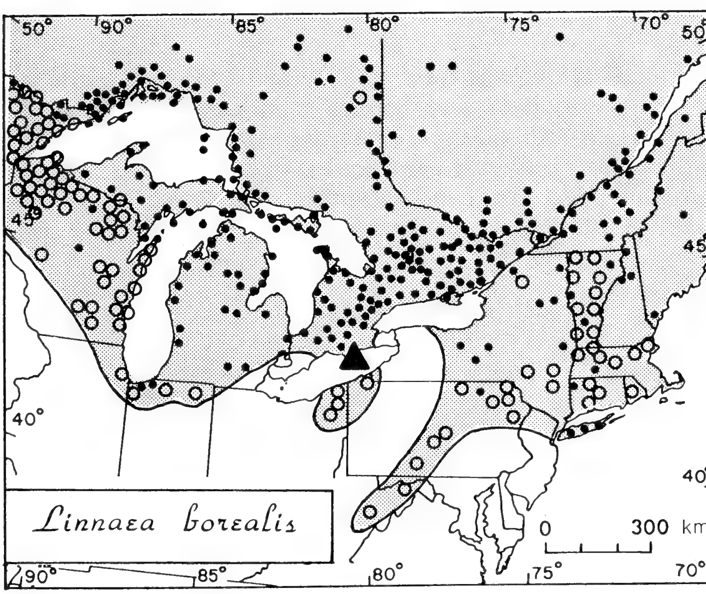


FIGURE 18. Distribution of Twinflower (*Linnaea borealis*) in the Great Lakes region based on specimens in CAN, DAO, MICH, and TRT. Open circles are literature records from Braun (1961), Deam (1940), House (1924), Lakela (1965), Mohlenbrock and Ladd (1978), Seymour (1982), Strausbaugh and Core (1978), Wade and Wade (1940), and Wherry et al. (1979).

TABLE 5. Northern Species in the flora of Long Point. Species are in the same order as in the *"Annotated List of Vascular Plants."* Names preceded by an asterisk were not seen during this survey.

| | | |
|---|---|---|
| *Equisetum variegatum* | *Eriophorum gracile* | *Polygala paucifolia* |
| *Pinus strobus* | *Rhynchospora alba* | * *Aralia hispida* |
| *Larix laricina* | *Scirpus subterminalis* | * *Cornus canadensis* |
| *Juniperus communis* | *Calla palustris* | * *C. rugosa* |
| *Thuja occidentalis* | *Juncus alpinoarticulatus* | *Arctostaphylos uva-ursi* |
| *Sparganium minimum* | *J. balticus* | * *Pterospora andromedea* |
| * *Potamogeton epihydrus* | *Tofieldia glutinosa* | * *Pyrola chlorantha* |
| *P. filiformis* | *Corallorhiza trifida* | *Trientalis borealis* |
| *Triglochin palustre* | *Platanthera hyperborea* | *Menyanthes trifoliata* |
| *Agropyron trachycaulum* | *Spiranthes romanzoffiana* | *Calystegia spithamea* |
| *Agrostis scabra* | *Populus tremuloides* | *Agalinis paupercula* |
| *Festuca saximontana* | *Salix pedicellaris* | *Utricularia minor* |
| *Glyceria borealis* | * *S. cordata* | *U. intermedia* |
| *Muhlenbergia glomerata* | *S. myricoides* | *Galium trifidum* |
| *Carex aurea* | *Betula papyrifera* | *Linnaea borealis* |
| *C. chordorrhiza* | *Arabis drummondii* | *Sambucus pubens* |
| * *C. crawfordii* | *A. lyrata* | *Campanula uliginosa* |
| *C. diandra* | *Cardamine pratensis* | *Lobelia kalmii* |
| *C. disperma* | * *Actaea rubra* | *Aster borealis* |
| *C. garberi* | *Drosera rotundifolia* | *Bidens discoidea* |
| *C. limosa* | *Parnassia glauca* | *Cirsium muticum* |
| *C. viridula* | *Potentilla anserina* | *Solidago hispida* |
| *Eleocharis quinqueflora* | *P. palustris* | *S. ptarmicoides* |

*edentula,* which are almost totally confined to the immediate lakeshores. On the Point, *Ammophila breviligulata* dominates extensive areas of active dunes; *Cakile edentula, Corispermum hyssopifolium, Euphorbia polygonifolia,* and *Triplasis purpurea* are frequent in areas of strand, upper beach, and open dunes; and *Carex crawei* and *Hypericum kalmianum* are important species of interdunal wet meadows.

## WESTERN SPECIES

Long Point is probably too far east to have been a contiguous part of the "Prairie Peninsula" (Transeau 1935). Also, being only about 4000 years old, it formed too late to have been influenced by the warmer and drier hypsithermal period which occurred about 4000 to 8000 years ago (Deevey & Flint 1957). Nevertheless, the drier meadows, especially those near the base of the Point dominated by *Andropogon scoparius* and *Sorghastrum nutans* are very prairie-like (Catling 1976) and they, in fact, harbor a few species of prairies whose distribution is almost entirely to the west of the Point. The best examples of prairie species on the Point are *Spiranthes magnicamporum* (Fig. 22) and *Stipa spartea* (Barkworth 1978).

Another minor western element comprises species of primarily mid-

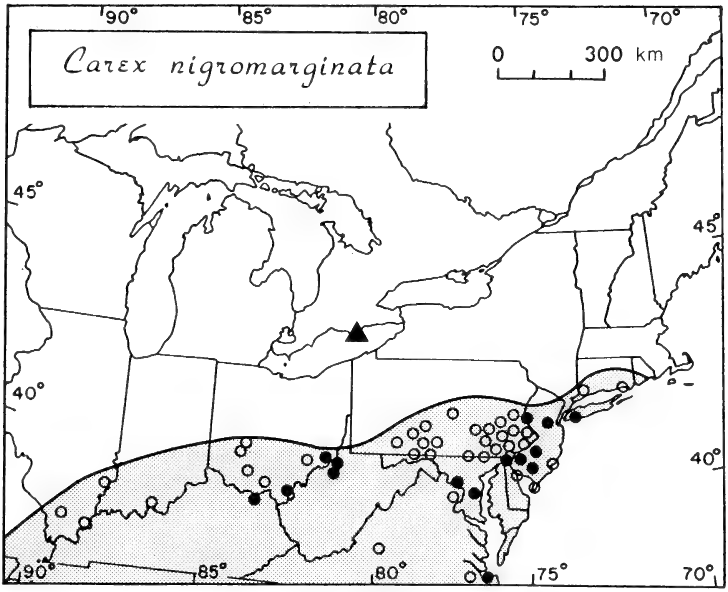


FIGURE 19. Distribution of the sedge *Carex nigromarginata* in the Great Lakes region based on specimens in CAN, DAO, MICH, and TRT. Open circles are literature records from Braun (1967), Deam (1940), Harvill et al. (1977), Mohlenbrock and Ladd (1978), Seymour (1982), Stone (1911), Tatnall (1946), and Wherry et al. (1979).

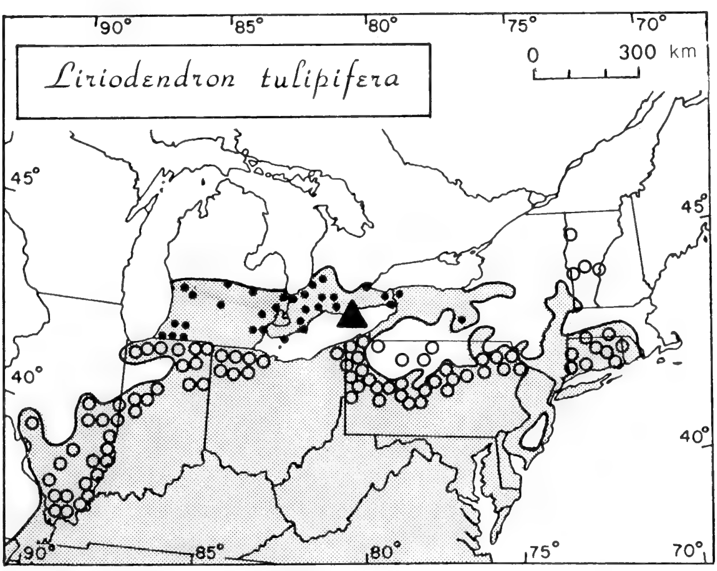


FIGURE 20. Distribution of Tulip Tree (*Liriodendron tulipifera*) in the Great Lakes region based on specimens in CAN, DAO, MICH, TRT (dots), and on Little (1971). Open circles are literature records from Braun (1961), Deam (1940), Mohlenbrock and Ladd (1978), Seymour (1982), and Wherry et al. (1979).

TABLE 6. Southern species in the Long Point flora. Species are in the same order as in the *"Annotated List of Vascular Plants."* Letters used in the HABITAT CLASS are defined as follows: P = prairie, savana, or dune; W = wetland; F = forest.

| SPECIES | HABITAT CLASS | SPECIES | HABITAT CLASS |
|---|---|---|---|
| *Aristida necopina* | P | *Nuphar advena* | W |
| *Cenchrus longispinus* | P | *Liriodendron tulipifera* | F |
| *Echinochloa walteri* | W | *Sassafras albidum* | F |
| *Muhlenbergia tenuiflora* | F | *Arabis laevigata* | F |
| *Triplasis purpurea* | P | *Platanus occidentalis* | F |
| *Vulpia octoflora* | P | *Strophostyles helvula* | P |
| *Carex alata* | W | *Linum medium* var. *texanum* | P |
| *C. artitecta* | F | *Ptelea trifoliata* | P |
| *C. nigromarginata* | F | *Parthenocissus quinquefolia* | F |
| *Cyperus erythrorhyzos* | W | *Vitis aestivalis* | F |
| *C. flavescens* | W | *Hibiscus moscheutos* | W |
| *Eleocharis caribaea* | W | *Cornus drummondii* | W |
| *E. engelmannii* | W | *Onosmodium molle* | F |
| *E. equisetoides* | W | *Pycnanthemum verticillatum* | P |
| *E. quadrangulata* | W | *Justicia americana* | W |
| *Peltandra virginica* | W | *Galium pilosum* | F |
| *Corallorhiza odontorhiza* | F | *Aster dumosus* | P |
| *Polygonum virginianum* | F | *Bidens coronatus* | W |
| *Nelumbo lutea* | W | *Liatris cylindracea* | P |

TABLE 7. Species in the Long Point flora mostly or entirely restricted to the Great Lakes shorelines within the Great Lakes region. Species are in the same order as in the *"Annotated List of Vascular Plants."*

| | |
|---|---|
| *Ammophila breviligulata* | *Cakile edentula* |
| *Triplasis purpurea* | *Potentilla paradoxa* |
| *Carex crawei* | *Prunus pumila (sensu stricto)* |
| *C. garberi* | *Lathyrus japonicus* |
| *Salix cordata* | *Euphorbia polygonifolia* |
| *S. myricoides* | *Hypericum kalmianum* |
| *Corispermum hyssopifolium* | *Satureja glabella* |

western lowland forests and thickets. Included here would be species such as *Celtis occidentalis, Cornus drummondii, Quercus macrocarpa,* and *Salix amygdaloides.* Compared to areas of Ontario with clay soils farther to the west and south, this element is small. A couple of western species not fitting easily into any category are the disjuncts *Pterospora andromedea* of White Pine forests (Marquis & Voss 1981) and *Potentilla paradoxa* of beach strands (Keddy 1984).

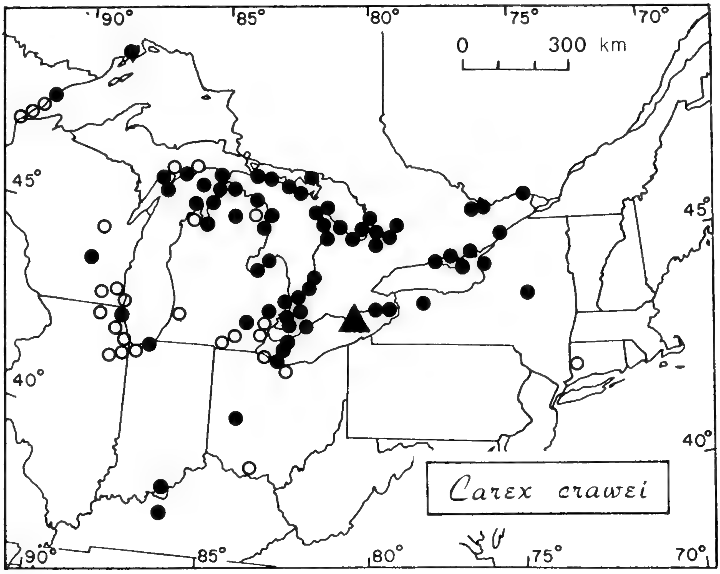


FIGURE 21. Distribution of the sedge *Carex crawei* in the Great Lakes region based on specimens in CAN, DAO, MICH, and TRT. Open circles are literature records from Braun (1967), Deam (1940), House (1924), Lakela (1965), Mohlenbrock and Ladd (1978), Seymour (1982), Voss (1972), and Zimmerman (1976).

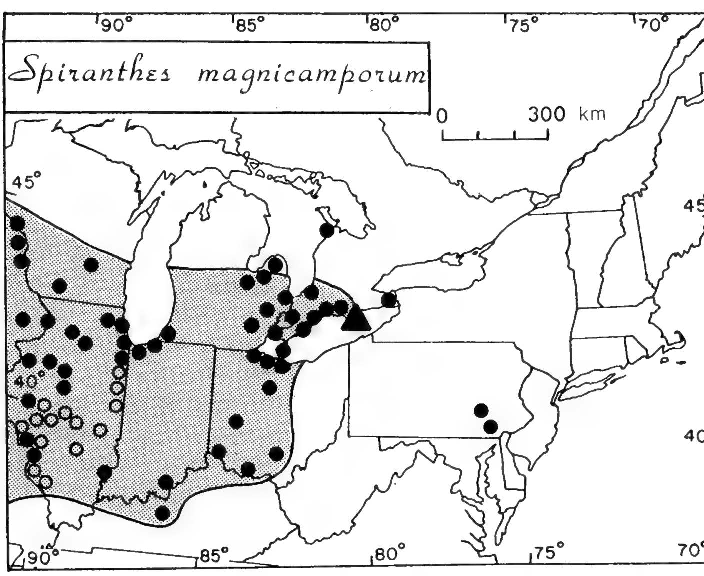


FIGURE 22. Distribution of Great Plains Ladies'-Tresses (*Spiranthes magnicamporum*) in the Great Lakes region based on specimens examined in CAN, DAO, MICH, and TRT, and by Catling (1980) and Case and Catling (1983). Open circles are literature records from Sheviak (1974).

*7. Comparison of the Floras of Long Point, Point Pelee National Park, and Rondeau Provincial Park*

Long Point is one of three large peninsulas on the north shore of Lake Erie. The other two, Point Pelee National Park and Rondeau Provincial Park, are also important natural areas. All three peninsulas are sandspits several thousands of years old formed from sand eroded from headlands elsewhere along the lakeshore. All three are composed of dune ridges and interdunal depressions and shelter extensive associated marshes. Long Point protrudes much further into Lake Erie either Point Pelee or Rondeau. In area, Long Point is substantially larger, being about 6450 ha contrasted with about 1970 ha for Point Pelee and about 1560 ha for Rondeau. Long Point is oriented essentially in an east-west direction, while Point Pelee and Rondeau are both oriented north-south. Each peninsula also has a unique shape, vegetation, land use history, and flora. Nevertheless, a comparison of the floras of the three Points is helpful to understanding the major factors responsible for Long Point's distinctive flora.

The sandspit nearest to Long Point is Presque Isle, Erie County, Pennsylvania, just across Lake Erie on the south shore. However, Presque Isle is substantially smaller and the only published complete floristic and vegetation survey is long outdated (Jennings 1909).

Heffernan and Nelson (1979) presented a detailed comparison of land use and vegetation for the three sandspits, noting that their study was only made possible by the completion in 1977 of a vegetation map for Long Point. The floras of both Point Pelee and Rondeau have been extensively surveyed over a long period and reasonably complete lists are available. Ours is the first attempt at a comprehensive list of plants for all of Long Point. Although there are undoubtedly some rare native and non-native species that remain to be discovered, the floras of the three sandspits can now be compared in terms of floristic composition (Fig. 23).

The first aspect of comparison is that the floras of the three sandspits are comparable in species number. The list for Point Pelee (Jellicoe 1984; with recent additions supplied by M.J. Oldham) presently totals 766 species; that for Rondeau (Ontario Ministry of Natural Resources 1979; with recent additions supplied by A. Woodliffe and M.J. Oldham) presently totals 797 species; and the Long Point list totals 691 species. The lower total for Long Point is probably largely due to the fact that much less botanical work has been conducted there than on the other two Points.

At the level of vegetation, the most striking contrast between the three sandspits is that Long Point has extensive areas dominated by northern tree species, including *Betula papyrifera, Larix laricina, Pinus strobus,* and *Thuja occidentalis.* These species dominate communities on both dry and wet sites. The other two sandspits have small areas with *Pinus strobus,* but the other species are absent. Long Point is also unique in having areas of floating sedge and *Sphagnum* mats around the margins of some ponds. In these vegetation types occur many northern species not found on the other two peninsulas. This trend is readily seen in Fig. 23, which compares num-

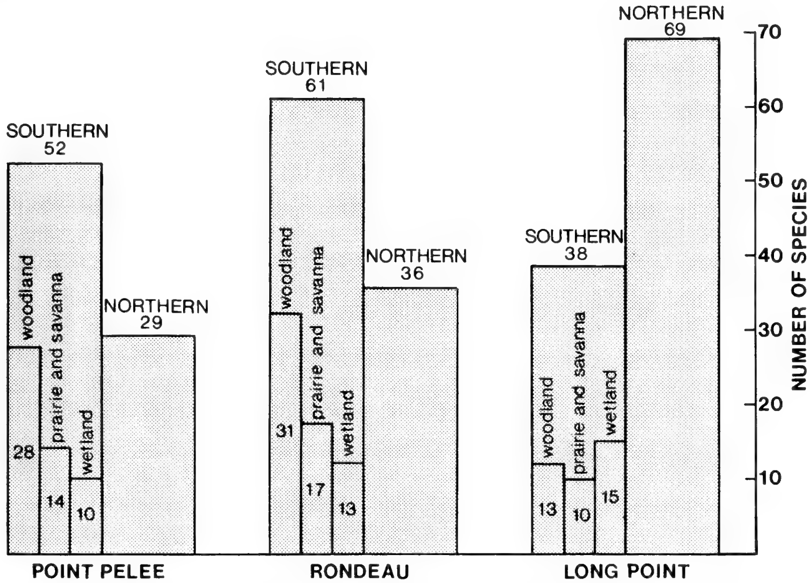


FIGURE 23. Histograms comparing the number of species in different categories reported from Long Point, Point Pelee National Park, and Rondeau Provincial Park. Southern species are subdivided into habitat classes as listed in Table 6.

bers of northern and southern species found on the three sandspits. Typical examples of northern species recorded only from Long Point include *Carex chordorrhiza, C. limosa, Corallorhiza trifida, Cornus canadensis, Eriophorum gracile, Linnaea borealis, Pyrola chlorantha, Salix pedicellaris,* and *Triglochin palustre.* In most cases, these species are not only absent from Rondeau and Point Pelee, but are rare throughout the Lake Erie region.

Another major vegetational contrast between Long Point and the other two sandspits is that the dominant upland communities of both Point Pelee and Rondeau are various types of deciduous forest. On Long Point, deciduous forest is a very rare community, with a single major occurrence at the east end of Squires Ridge and only small remnants elsewhere. The most extensive upland community on Long Point is Oak savanna. Thus, many common and widespread deciduous forest understory species frequent on Point Pelee and Rondeau are altogether lacking on Long Point. Examples include *Allium tricoccum* Aiton, *Claytonia virginica* L., *Dentaria laciniata* Willd., *Hepatica acutiloba* DC., *Hydrophyllum virginianum* L., *Pedicularis canadensis* L., *Phlox divaricata* L., *Sanguinaria canadensis* L., and *Uvularia grandiflora* Smith. Those deciduous forest understory species that are present on Long Point, such as *Anemone quinquefolia, Podophyllum peltatum, Polygonatum pubescens,* and *Viola rostrata* are very rare and local indeed. The few areas of deciduous forest on the Point have understories mostly dominated by shade tolerant grasses and sedges rather than forbs,

probably due to the grazing pressure of the very large Long Point deer herd.

In Fig. 23, the southern species are, for each sandspit, divided into three categories: deciduous forest species; prairie, savanna, or dune species; and wetland species. A major factor in Long Point having fewer southern species is clear from this division; Long Point has less than half the number of southern deciduous forest species of either Point Pelee or Rondeau. Also noticeable on Fig. 23 is that Long Point has conspicuously fewer southern prairie, savanna, or dune species than either Point Pelee or Rondeau. The great expanses of Oak savanna on Long Point appear to have their origin almost entirely from recently degraded forest and do not have a well-developed savanna flora, in contrast to the richer floras of the much smaller areas of savanna on Point Pelee and especially Rondeau. On the other hand, the wetlands on Long Point are much more extensive and diverse than those of Point Pelee and Rondeau. Only in numbers of wetland species of southern affinity does Long Point exceed Point Pelee and Rondeau. In all these respects, the floras of Point Pelee and Rondeau are more similar to each other than either are to that of Long Point. With respect to rare species only (based on Argus et al. (1982 -1987)), both Rondeau and Pelee have more rare species than Long Point; 55 and 49 respectively, compared to 42 for Long Point. Again, this is largely due to the lack of southern deciduous forest species on Long Point, as well as, of course, the less intensive botanical work on Long Point. The very similar profiles of the Point Pelee and Rondeau floras are certainly evident in Fig. 23.

Finally, intensive human alterations of the landscape, such as road building and agricultural and residential development, have been much more limited on Long Point and Rondeau than at Point Pelee (Heffernan & Nelson 1979). As expected, the non-native component of the Long Point and Rondeau floras (ca. 20% of the total) is substantially less than that of Point Pelee (ca. 27%).

## *8. Annotated List of Vascular Plants*

Families recognized in this list and their order follow Gleason and Cronquist (1963) for convenience. Genera are alphabetical within families and species are alphabetical within genera. The estimated abundance of species is divided into three categories: rare, occasional, and abundant. Similarly, distribution of species throughout Long Point is divided into three categories: local, scattered, and widespread. The descriptions of abundance and distribution of species on the Point were assigned as follows from field notes and observations:

**rare** - few individuals or clones (mostly less than two dozen)
**occasional** - numerous, but more or less readily estimable as several dozen to several hundred individuals
**abundant** - too numerous to estimate, but probably many hundreds or thousands of individuals

**local** - one or a few, isolated sites
**scattered** - several to many somewhat discontinous sites
**widespread** - occurring essentially throughout

If a plant was found only in a particular, small area, a specific location (using place names in Fig. 1) may also be given. Specific locations are always given for species found in Haldimand-Norfolk only on Long Point or species rare in Ontario (Tables 1 & 2), if the species are confined to a restricted area on the Point. Habitat descriptions follow those given in the text *Vegetation Patterns.* If a habitat is given, the plant was seen by us during this survey, even if the voucher cited is not one of our collections. If we collected a voucher of a species, only the collection number is cited. The first set of our collections is at DAO, with almost all numbers also represented by duplicates at MICH. Otherwise, the collector and number (or date, if no number was used), as well as the herbarium in which the specimen is housed, are given. Only one specimen per species, the most recent collection, is cited except for our own numbers. If the species was not seen during our survey and the most recent collection seen predates 1979, the date is always given. Non-native species are marked with an asterisk.

Nomenclature follows up-to-date research insofar as we were aware of it. If a name used is unfamiliar, i.e., not in use in at least one current flora for a surrounding region, a reference is given and a synonym is provided. *Flora Europaea* (Tutin et al. 1964–1980) has been followed for introduced species of European origin unless otherwise stated. In general, subspecies or varietal designations are not used in this list except in a few cases where varieties or subspecies are often recognized at species rank or where more than one distinctive subspecies or variety could occur on the Point.

## PTERIDOPHYTES

### LYCOPODIACEAE

*Lycopodium digitatum* A. Braun (*L. flabelliforme*), club-moss—Rare and local on mossy hummocks and steep banks in Red Oak-Sugar Maple forest on Squires Ridge (*6115*). (Hickey & Beitel 1979).

### SELAGINELLACEAE

*Selaginella apoda* (L.) Spring (incl. *S. eclipes*), meadow spikemoss—Occasional and scattered on bare, moist sand in wet sedge meadows (*5399, 5451*).

### EQUISETACEAE

*Equisetum arvense* L., field horsetail—Abundant and widespread in many terrestrial habitats (*5465*).

*E. fluviatile* L., water horsetail—Occasional and scattered in emergent wetlands (*5577*).

*E. hyemale* L., scouring-rush—Occasional but widespread in many habitats (*5989*).

*E.* ×*nelsonii* A.A. Eaton (*E. laevigatum* × *E. variegatum*)—Not seen during this survey; *E. laevigatum* is not known from the Point (*Sutherland 7532*, MICH).

*E.* ×*trachydon* A. Braun (*E. hyemale* × *E. variegatum*)—Rare and local in wet sedge meadows (*6410*).

*E. variegatum* Schleich., variegated horsetail—Occasional and scattered in wet sedge meadows, but sometimes forming dense stands over small areas (*5310*).

OPHIOGLOSSACEAE

*Botrychium virginianum* (L.) Sw., rattlesnake fern—Rare and local in White Pine-White Cedar-Red Cedar forest (*5454*).

OSMUNDACEAE

*Osmunda cinnamomea* L., cinnamon fern—Rare and local in Tamarack-White Cedar swamp (*5460*).

*O. regalis* L., royal fern—Rare and local in Tamarack-White Cedar swamp (*5646*).

POLYPODIACEAE

*Asplenium platyneuron* (L.) D.C. Eaton, ebony spleenwort—Occasional and scattered in Oak savanna, Red Oak-Sugar Maple forest, and White Pine-White Cedar-Red Cedar forest, especially at the bases of north-facing slopes (*5283*).

*Athyrium filix-femina* (L.) Roth, lady fern—Occasional and local in Red Oak-Sugar Maple forest (*6105*).

*Cystopteris tenuis* (Michaux) Desv. (*C. fragilis* of authors), fragile fern—Occasional and local in Red Oak-Sugar Maple forest (*5382*). (Moran 1983).

*Dryopteris carthusiana* (Villars) H.P. Fuchs (*D. spinulosa*), spinulose wood-fern—Rare and local in Red Oak-Sugar Maple forest (*5381*). (Fraser-Jenkins 1980).

*D. intermedia* (Willd.) A. Gray, evergreen wood-fern—Rare at one site, in Scots Pine reforestation at the base of the Point (*5685*).

*D. marginalis* (L.) A. Gray, marginal wood-fern—Occasional but widespread in Oak savanna, Red Oak-Sugar Maple forest, and White Pine-White Cedar-Red Cedar forest, especially on north-facing slopes (*5285*).

*Onoclea sensibilis* L., sensitive fern—Occasional but widespread in wet depressions in Red Oak-Sugar Maple forest, Oak savanna, and Tamarack-White Cedar swamp (*5581*).

*Polypodium virginianum* L., rock-polypody—Rare at one site, in moss at base of steep north-facing slope in Red Oak-Sugar Maple forest (*5480*).

*Polystichum acrostichoides* (Michaux) Schott, christmas fern—Rare and local on north-facing slopes in Red Oak-Sugar Maple forest (*5377*).

*Pteridium aquilinum* (L.) Kuhn, bracken fern—Abundant and widespread in Oak savanna, Red Oak-Sugar Maple forest, and White Pine-White Cedar-Red Cedar forest (*Heffernan* in 1976, DAO).

*Thelypteris palustris* Schott, marsh fern—Abundant and widespread in wet meadows, Tamarack-White Cedar swamp, and emergent wetlands (*5971*).

## GYMNOSPERMS

PINACEAE

*Larix laricina* (Duroi) K. Koch, tamarack—Abundant and widespread, a major dominant of Tamarack-White Cedar swamp (*5582*).

**Picea glauca* (Moench) A. Voss, white spruce—Rare and local, seedlings from planted trees in Oak savanna and Red Oak-Sugar Maple forest (*Falls & Klawe 772*, TRT).

*Pinus strobus* L., white pine—Abundant and widespread in White Pine-White Cedar-Red Cedar forest and Oak savanna, locally a major dominant (*6114*).

**P. sylvestris* L., Scots pine—Occasional and local, seedlings from planted trees on dry dunes and in wet meadows near the base of the Point, potentially a dangerous pest (*5671*).

*Tsuga canadensis* (L.) Carr., hemlock—Rare and local in Red Oak-Sugar Maple forest and Oak savanna (*5367*).

CUPRESSACEAE

*Juniperus communis* L., common juniper—Abundant and widespread in Cottonwood-Red Cedar savanna and openings in White Pine-White Cedar-Red Cedar forest (*5446*).

*J. virginiana* L., red cedar—Abundant and widespread, a major dominant of

Cottonwood-Red Cedar savanna and White Pine-White Cedar-Red Cedar forest (*5532*).

*Thuja occidentalis* L., white cedar—Abundant and widespread, a major dominant of White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*5486*).

## MONOCOTS

### TYPHACEAE

**Typha angustifolia* L., narrow-leaved cat-tail—Rare and local in emergent wetlands (*6076*).

*T. ×glauca* Godron (*T. angustifolia* × *T. latifolia*), hybrid cat-tail— Abundant and widespread in emergent wetlands, the most abundant cat-tail on the Point and the major dominant of the marshes of the inner bay (*6047*).

*T. latifolia* L., common cat-tail—Abundant and widespread in emergent wetlands and wet meadows (*6095*).

### SPARGANIACEAE

*Sparganium chlorocarpum* Rydb.—Occasional and scattered in emergent wetlands (*5274*).

*S. eurycarpum* Engelm.—Abundant and widespread in emergent wetlands (*5600*).

*S. minimum* (Hartman) Fries—Rare and local in submerged or floating-leaved aquatic communities in inland pools between the Little Creek Ridges and Gravelly Bay (*5363*).

### NAJADACEAE

*Najas flexilis* (Willd.) Rostk. & Schmidt—Occasional but widespread in submerged aquatic communities (*5346, 5361*).

*N. gracillima* (A. Braun) Magnus—Not seen during this survey (*Woodley 79-33*, OAC). This collection, from a pond in the Big Creek Conservation Area, appears correctly identified, although there is no mature fruit. Its occurrence in this area, in water of pH 9, is rather unusual, since it occurs mostly in soft waters, but we are not aware of any reason to suspect a labelling error.

*N. guadalupensis* (Sprengel) Magnus—Rare and local in submerged aquatic communities (*5316*).

*Potamogeton amplifolius* Tuckerman—Rare and local in submerged aquatic communities (*5968*).

**P. crispus* L., curly-leaved pondweed—Abundant and scattered in submerged aquatic communities in waters connected to Lake Erie (*5550*).

*P. epihydrus* Raf.—Not seen during our survey (*Landon* in 1951, OAC).

*P. filiformis* Pers.—Occasional at one site in shallow water of sandy bottomed shoreline along the north beach near Squires Ridge (*5386*).

*P. foliosus* Raf.—Occasional but widespread in submerged aquatic communities (*5351, 5965*).

*P. friesii* Rupr.—Rare and local in submerged aquatic communities of the inner bay (*5275*).

*P. gramineus* L.—Abundant and widespread in various submerged aquatic communities (*5322, 5964*).

*P. ×haynesii* Hellquist & Crow (*P. strictifolius* × *P. zosteriformis*)—Rare at one site in shallow water opening in cattail marsh near Ryerson's Island (*6045*). (Hellquist & Crow 1986). Det. C.B. Hellquist & G.E. Crow.

*P. illinoensis* Morong—Abundant and widespread in various submerged aquatic communities (*5265*).

*P. natans* L.—Abundant and widespread in various submerged and floating-leaved aquatic communities (*5280*).

*P. nodosus* Poiret—Abundant at one site in a small pool in a Tamarack-White Cedar swamp near Gravelly Bay (*5999*).

*P. pectinatus* L., sago pondweed—Abundant and widespread in various submerged aquatic communities (*6035*).

*P. perfoliatus* L.—Not seen during this survey (*Senn & Soper 410* in 1938, DAO).

*P. pusillus* L. (incl. *P. berchtoldii*)—Abundant and widespread in various submerged aquatic communities (*5633, 6044*).

*P. richardsonii* (A. Bennett) Rydb. red-head pondweed—Occasional and scattered in various submerged aquatic communities (*6077*).

*P. robbinsii* Oakes—Rare but widespread in submerged aquatic communities in inland pools (*5967*).

*P. strictifolius* A. Bennett—Not seen during this survey (*Ashenden* in 1981, DAO).

*P. zosteriformis* Fern., flat-stem pondweed—Rare and scattered in various submerged aquatic communities (*5268*).

JUNCAGINACEAE

*Triglochin maritimum* L.—Occasional but widespread in wet sedge meadows (*5981, 6029*).

*T. palustre* L.—Occasional but widespread in wet sedge meadows (*5306, 6028*).

ALISMATACEAE

*Alisma plantago-aquatica* L.(incl. *A. triviale* and *A. subcordatum*), water-plantain—Occasional and scattered in wet sedge meadows and emergent wetlands (*5982*).

*Sagittaria cuneata* Sheldon—Occasional but widespread in wet sedge meadows and shallow emergent wetlands (*6074, 6409*).

*S. graminea* Michaux var. *cristata* Engelm., grass-leaved arrowhead—Rare but widespread in shallow emergent wetlands in inland pools (*5970* [fruiting]; *Hart 594*, DAO; *Senn & Soper 594*, TRT).

*S. latifolia* Willd., broad-leaved arrowhead—Abundant and widespread in emergent wetlands (*5347*).

*S. rigida* Michaux, sessile-fruited arrowhead—Occasional but widespread in emergent wetlands (*6036*).

BUTOMACEAE

**Butomus umbellatus* L., flowering-rush—Abundant but local in emergent wetlands (*5348, 6037*).

HYDROCHARITACEAE

*Elodea canadensis* Michaux—Abundant and widespread in various emergent wetlands (*5238, 5231*).

*E. nuttallii* (Planchon) H. St. John—Abundant at one site in shallow water at the base of the Point (*3824*).

*Vallisneria americana* Michaux, wild-celery—Abundant but scattered in various submerged aquatic communities (*6075*).

POACEAE

**Agropyron repens* (L.) Beauv., quack grass—Occasional but widespread in Oak savanna and weedy habitats (*6148*).

*A. trachycaulum* (Link) Malte, wheatgrass—Rare and local in White Pine-White Cedar-Red Cedar forest (*5298*).

**Agrostis gigantea* Roth (*A. alba*), redtop—Abundant but scattered in weedy habitats (*6009*).

*A. perennans* (Walter) Tuckerman, upland bent—Occasional and local in Red Oak-Sugar Maple forest (*5354*).

*A. scabra* Willd., ticklegrass—Rare and local in wet sedge meadows (*6015*).

**A. stolonifera* L., creeping bent—Occasional but widespread in wet meadows, weedy habitats, and on beach strands (*8369*).

*Ammophila breviligulata* Fern., beach grass—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna (*6021*).

*Andropogon scoparius* Michaux, little bluestem—Abundant and widespread on dry

dunes, and in Cottonwood-Red Cedar savanna, clearings in White Pine-White Cedar-Red Cedar forest, and occasionally in wet sedge meadows (*Klawe 750,* TRT).

*Aristida necopina* Shinn. (*A. intermedia* of authors), three-awned grass—Abundant but local in drier edges of wet sedge meadows near Gravelly Bay; rare near the base of the Point (*5319*).

**Bromus inermis* Leysser, smooth brome—Not seen during this survey (*Landon n.d.*, HAM).

*B. latiglumis* (Shear) A. Hitchc.—Rare and local in Red Oak-Sugar Maple forest (*5291*).

*B. pubescens* Willd., Canada brome—Rare at one site at the base of a steep, north-facing slope in Red Oak-Sugar Maple forest (*5385*).

**B. secalinus* L., chess—Not seen during this survey (*Reznicek 4019* in 1973, TRTE).

**B. tectorum* L., downy chess—Abundant and widespread in weedy habitats, Oak savanna, and on dry dunes (*5518*).

*Calamagrostis canadensis* (Michaux) Beauv., blue-joint—Abundant and widespread in wet meadows, emergent wetlands, and wet depressions in various communities; occasionally in quite dry sites in Oak savanna (*5978*).

*Cenchrus longispinus* (Hackel) Fern., sandbur—Occasional but widespread on dry dunes, beach strands, and in weedy habitats (*5401*).

**Dactylis glomerata* L., orchard grass—Rare and local in weedy habitats (*5559*).

*Danthonia spicata* (L.) Roemer & Schultes, poverty grass—Occasional but widespread in Red Oak-Sugar Maple forest, Oak savanna, White Pine-White Cedar-Red Cedar forest, and on dry dunes (*5357, 6107*).

*Dichanthelium acuminatum* (Sw.) Gould & C.A. Clark var. *fasciculatum* (Torrey) Freckmann (*Panicum implicatum, D. acuminatum* var. *implicatum*)—Occasional but widespread in wet meadows, Cottonwood-Red Cedar savanna, and Oak savanna (*5639*). (Gould & Clark 1978, Freckmann 1981).

*D. latifolium* (L.) Gould & C.A. Clark (*Panicum latifolium*)—Rare and local in Red Oak-Sugar Maple forest (*6119*). (Gould & Clark 1978).

*D. lindheimeri* (Nash) Gould (*Panicum lindheimeri*)—Rare and local in wet meadows (*6013*). (Gould 1974).

*D. linearifolium* (Scribner) Gould (*Panicum linearifolium*)—Occasional and scattered in less disturbed Oak savanna (*5375*). (Gould 1974).

*D. oligosanthes* (Schultes) Gould (*Panicum oligosanthes*)—Occasional but widespread in Oak savanna and Cottonwood-Red Cedar savanna (*5654*). (Gould 1974).

**Digitaria ischaemum* (Schreber) Muhlenb., smooth crab grass—Occasional and local in weedy habitats (*6150*).

**D. sanguinalis* (L.) Scop., hairy crab grass—Occasional and local in weedy habitats (*6131*).

**Echinochloa crusgalli* (L.) Beauv.—Occasional and local on beach strands and in weedy habitats (*5405*).

*E. muricata* (Beauv.) Fern.—Occasional but widespread on beach strands and in weedy habitats (*5327*).

*E. walteri* (Pursh) A.A. Heller—Rare but widespread on beach strands (*5325*).

*Elymus canadensis* L., Canada wild-rye—Abundant and widespread on dry dunes, in Cottonwood-Red Cedar savanna, and in Oak savanna (*5984*).

*E. hystrix* L. (*Hystrix patula*), bottlebrush grass—Occasional and local in Red Oak-Sugar Maple forest (*6026*). (Dore & McNeill 1980).

*E. villosus* Willd.—Occasional and local in Red Oak-Sugar Maple forest (*5264*).

*E. virginicus* L., terrell grass—Rare and local in Red Oak-Sugar Maple forest and dense, shrubby Cottonwood savanna on Ryerson's Island (*6066*).

*Eragrostis frankii* Steudel—Rare and local in weedy habitats (*5406*).

*E. hypnoides* (Lam.) BSP.—Rare on beach strands near the base of the Point (*8371*).

**E. minor* Host (*E. poaeoides*)—Rare and local in weedy habitats (*6421*). (McNeill & Dore 1979).

*E. pectinacea* (Michaux) Nees—Occasional and local in weedy habitats and on beach strands (*5402*).

*Festuca arundinacea* Schreber, tall fescue—Occasional and scattered in weedy habitats (*5557*).
*F. obtusa* Biehler, nodding fescue—Occasional and local in Red Oak-Sugar Maple forest (*5667*).
**F. pratensis* Hudson (*F. elatior* of authors), meadow fescue—Occasional and scattered in weedy habitats (*5558*).
**F. rubra* L., red fescue—Occasional and scattered in weedy habitats (*5567*).
*F. saximontana* Rydb.—Rare; one patch of ca. 1 $m^2$ in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*5342*).
*Glyceria borealis* (Nash) Batch., float grass—Rare and local in shallow water of emergent wetlands in inland pools (*5629*).
*G. grandis* S. Watson, reed-meadow grass—Occasional and scattered in emergent wetlands (*Neal 607*, DAO).
*G. striata* (Lam.) A. Hitchc., fowl manna grass—Occasional but widespread in wet sedge meadows and Tamarack-White Cedar swamp (*5584*).
*Leersia oryzoides* (L.) Sw., cut grass—Occasional and scattered on beach strands, and in wet meadows, emergent wetlands, and Tamarack-White Cedar forest (*Johnson* in 1972, TRT).
**Lolium perenne* L., ryegrass—Rare and local in weedy habitats (*6162*).
*Muhlenbergia frondosa* (Poiret) Fern.—Occasional and scattered in Red Oak-Sugar Maple forest (*5355*).
*M. glomerata* (Willd.) Trin., marsh wild-timothy—Rare and local in wet sedge meadows (*6092*).
*M. mexicana* (L.) Trin.—Occasional but widespread in Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, and Oak savanna (*5358*).
*M. schreberi* J. Gmelin, nimblewill—Occasional and local in Red Oak-Sugar Maple forest (*5356*).
*M. tenuiflora* (Willd.) BSP.—Occasional and local in Red Oak-Sugar Maple forest on Squires Ridge (*5384*).
*Oryzopsis asperifolia* Michaux, rice-grass—Occasional and local in White Pine-White Cedar-Red Cedar forest (*5458*).
*O. racemosa* (Smith) A. Hitchc.—Occasional and local in White Pine-White Cedar-Red Cedar forest (*5988*).
*Panicum capillare* L., witch grass—Occasional but widespread on beach strands, and in wet meadows, and weedy habitats (*6032*).
*P. dichotomiflorum* Michaux, fall panicum—Occasional and local in weedy habitats (*Sutherland 8054*, MICH).
*P. flexile* (Gattinger) Scribner—Occasional and local in wet meadows on areas of bare soil (*5311*).
*P. gattingeri* Nash—Not seen during this survey (*Oldham 7926*, DAO, MICH, TRTE).
*P. tuckermanii* Fern.—Rare but widespread on the strand of the north beach and near the base of the Point (*5330*).
*P. virgatum* L., switch grass—Abundant and widespread on dry dunes, and in Cottonwood-Red Cedar savanna, Oak savanna, and wet meadows (*6121*).
*Phalaris arundinacea* L., reed canary grass—Occasional but widespread in wet meadows, emergent wetlands, and weedy habitats (*6060*).
**Phleum pratense* L., timothy—Occasional and scattered in weedy habitats (*5556*).
*Phragmites australis* (Cav.) Steudel (*P. communis*), reed—Abundant and widespread in emergent wetlands and wet meadows (*6043*).
**Poa annua* L., annual bluegrass—Occasional and local in weedy habitats (*5516*).
**P. compressa* L., Canada bluegrass—Abundant and widespread in Oak savanna, Cottonwood-Red Cedar savanna, weedy habitats, and on dry dunes (*6120*).
*P. languida* A. Hitchc.—Occasional and local in White Pine-White Cedar-Red Cedar forest and Red Oak-Sugar Maple forest (*5632*).
*P. palustris* L., fowl meadow grass—Occasional but widespread in wet meadows and emergent wetlands, less often in a variety of drier habitats and weedy sites (*5980, 6147*).

FIGURE 24. Needle Grass (*Stipa spartea*) in open Cottonwood (*Populus deltoides*) savanna on Bluff Island. Aug. 4, 1980.

*P. pratensis* L., Kentucky bluegrass—Abundant and widespread in Oak savanna and weedy sites (*5620*).

**Puccinellia distans* (Jacq.) Parl., alkali grass—Rare and local on gravelly roadsides (*5562*).

*Schizachne purpurascens* (Torrey) Swallen, false melic—Rare and local in White Pine-White Cedar-Red Cedar forest (*5462*).

**Setaria glauca* (L.) Beauv., yellow foxtail—Occasional but widespread in weedy habitats (*6135*).

**S. viridis* (L.) Beauv., green foxtail—Occasional but widespread in weedy habitats (*6113*).

*Sorghastrum nutans* (L.) Nash, indian grass—Abundant and widespread on dry dunes, in Cottonwood-Red Cedar savanna, and in wet meadows (*Senn & Soper 457*, TRT).

*Spartina pectinata* Link, cordgrass—Occasional and local in wet meadows and on dry dunes (*5990*).

*Sphenopholis intermedia* (Rydb.) Rydb., wedgegrass—Rare and local in Tamarack-White Cedar swamp (*5682*).

*Sporobolus cryptandrus* (Torrey) A. Gray, sand dropseed—Abundant and widespread on dry dunes, and in Cottonwood-Red Cedar savanna and Oak savanna (*6019*).

*S. neglectus* Nash—Rare and local in weedy habitats (*5396*).

*S. vaginiflorus* (Torrey) A. Wood—Rare and local in weedy habitats and wet meadows (*5320*).

*Stipa spartea* Trin., needle grass—Abundant at Bluff Point on dry dunes and in Oak savanna (*6079*). Figure 24.

*Triplasis purpurea* (Walter) Chapman, sand grass—Occasional but widespread on beach strands and dry dunes (*5288, 6399*).

*Vulpia octoflora* (Walter) Rydb. (*Festuca octoflora*), six-weeks fescue—Rare at one site

in a dry opening in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*5447*).

*Zizania aquatica* L., southern wild-rice—Occasional and local in emergent wetlands in the inner bay near the base of the Point (*6123*).

*Z. palustris* L., northern wild-rice—Abundant and widespread in emergent wetlands (*6071*).

CYPERACEAE

*Carex alata* Torrey—Rare; a single clump on a log in a Red Maple-dominated wet depression in Oak savanna on the ridge immediately east of Squires Ridge was discovered in 1980; examination in 1988 disclosed three clumps (*6034*).

*C. aquatilis* Wahlenb.—Occasional and scattered in emergent wetlands, wet meadows and openings in Tamarack-White Cedar swamp; locally a dominant (*5608*).

*C. artitecta* Mackenzie—Abundant and widespread in Red Oak-Sugar Maple forest; more local in Oak savanna and White Pine-White Cedar-Red Cedar forest (*5473, 5474, 5475, 5495, 5637, 5640, 5670*).

*C. aurea* Nutt.—Rare and local in Tamarack-White Cedar swamp (*5583*).

*C. bebbii* (L. Bailey) Fern.—Occasional but widespread in wet meadows (*5370*).

*C. blanda* Dewey—Abundant but scattered in Red Oak-Sugar Maple forest and Oak savanna (*5443, 5612*).

*C. brevior* (Dewey) Mackenzie—Occasional and local in Oak savanna and dry openings in White Pine-White Cedar-Red Cedar forest (*5642*).

*C. buxbaumii* Wahlenb.—Occasional but widespread in wet sedge meadows (*5530*).

*C. cephalophora* Willd.—Rare and scattered in Red Oak-Sugar Maple forest and Oak savanna (*5613*).

*C. chordorrhiza* L.f.—Occasional but widespread; at one site in floating sedge mats near Gravelly Bay and rarely forming vigorous plants on recently deposited wet sand at marsh edges along the south beach (*5624*).

*C. communis* L. Bailey—Rare and local in Red Oak-Sugar Maple forest (*5476*).

*C. comosa* Boott—Occasional and scattered in wet meadows and emergent wetlands (*5271*).

*C. crawei* Dewey—Abundant and widespread in wet sedge meadows (*5528, 5594*).

*C. crawfordii* Fern.—Not seen during this survey (*Landon* in 1949, OAC).

*C. cristatella* Britton—Occasional and local in wet depressions in Red Oak-Sugar Maple forest and Oak savanna (*6106*).

*C. cryptolepis* Mackenzie—Not seen during this survey (*Landon* in 1951, OAC).

*C. deweyana* Schwein.—Rare and local in Oak savanna (*5616*).

*C. diandra* Schrank—Abundant at one site near Gravelly Bay in a wet opening in Tamarack-White Cedar swamp (*5578*).

*C. disperma* Dewey—Rare and local in Tamarack-White Cedar swamp (*5631*).

*C. eburnea* Boott—Occasional and scattered, although very locally forming dense turf, in White Pine-White Cedar-Red Cedar forest, Tamarack-White Cedar swamp, and at the bases of north-facing slopes in Oak savanna (*6000*). Figure 25.

*C. foenea* Willd.—Rare and local in Oak savanna (*5483*).

*C. garberi* Fern.—Occasional but widespread in wet sedge meadows (*5590*).

*C. granularis* Willd.—Rare and local in wet sedge meadows (*5580*).

*C. interior* L. Bailey—Occasional and scattered in wet sedge meadows, especially in floating mats, and in Tamarack-White Cedar swamp (*5585, 5647*).

*C. lacustris* Willd.—Occasional and local in emergent wetlands and wet sedge meadows (*5552*).

*C. lanuginosa* Michaux—Rare and local in Oak savanna (*5352*).

*C. lasiocarpa* Ehrh.—Rare and local in wet sedge meadows (*5572*).

*C. laxiflora* Lam.—Not seen during this survey (*Landon* in 1949, HAM).

*C. limosa* L.—Rare and local in floating sedge mats (*5625, 5645*).

*C. lupulina* Willd.—Not seen during this survey (*Landon* in 1949, HAM, OAC).

*C. molesta* Bright—Rare at one site at the base of the Point in the weedy edge of an emergent wetland (*5565*).

FIGURE 25. Tussock of the sedge *Carex eburnea* in White Cedar (*Thuja occidentalis*) forest at the base of a dune ridge near Gravelly Bay. May 25, 1980.

*C. muhlenbergii* Willd.—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna and Oak savanna (*5665*).
*C. nigromarginata* Schwein.—Occasional and local on dry, acid hummocks in less disturbed Oak savanna (*5496, 5636, 5648*).
*C. peckii* Howe—Not seen during this survey (*Oldham 4180*, CAN).
*C. pedunculata* Willd.—Rare and local in Oak savanna (*5468b*).
*C. pensylvanica* Lam.—Abundant but local in Oak savanna and Red Oak-Sugar Maple forest (*5498*).
*C. pseudocyperus* L.—Rare and local in emergent wetlands (*5272*).
*C. radiata* (Wahlenb.) Small (*C. rosea* of authors)—Rare and local in Red Oak-Sugar Maple forest (*5372*). (Webber & Ball 1984).
*C. rosea* Willd. (*C. convoluta*)—Rare and local in Red Oak-Sugar Maple forest and Oak savanna (*5668*). (Webber & Ball 1984).
*C. rugosperma* Mackenzie—Occasional and scattered in less disturbed Oak savanna (*5497*).
*C. sartwellii* Dewey—Occasional and scattered in wet meadows and emergent wetlands (*5591*).
*C. sprengelii* Sprengel—Abundant at one site in Oak savanna at the western end of Courtright Ridge (*5501*).
*C. stipata* Willd.—Occasional and scattered in wet meadows, emergent wetlands, and Tamarack-White Cedar swamp (*5598*).
*C. stricta* Lam.—Abundant and widespread in wet meadows and emergent wetlands (*5570, 5571, 5610, 5611*).
*C. tetanica* Schk.—Rare but widespread in wet sedge meadows (*5531, 5586*).
*C. umbellata* Willd.—Not seen during this survey (*Oldham 4185*, CAN, MICH).

*C. viridula* Michaux—Occasional but widespread in wet sedge meadows (*6160*).
*C. vulpinoidea* Michaux—Occasional but widespread in wet meadows and weedy habitats (*5579*).
*Cladium mariscoides* (Muhlenb.) Torrey, twig-rush—Abundant and widespread in wet sedge meadows (*5972*).
*Cyperus bipartitus* Torrey (*C. rivularis*)—Occasional but widespread on beach strands and in wet, sandy meadows (*5335*). (Tucker 1983).
*C. diandrus* Torrey—Rare and local on beach strands and in wet, sandy meadows (*5333*).
*C. engelmannii* Steudel—Occasional but widespread on beach strands and in wet, sandy meadows (*5244, 5245*).
*C. erythrorhizos* Muhlenb.—Rare but widespread on beach strands (*5344*).
*C. esculentus* L., yellow nut-grass—Rare and local on beach strands (*5345*).
*C. flavescens* L.—Occasional and widespread on beach strands and in wet, sandy meadows (*5334*).
*C. odoratus* L.—Occasional and widespread on beach strands and in wet, sandy meadows (*5336, 5343*).
*C. strigosus* L.—Occasional but widespread on beach strands and in wet, sandy meadows (*5337*).
*Dulichium arundinaceum* (L.) Britton, three-way sedge—Occasional and local in wet meadows and emergent wetlands (*5273*).
*Eleocharis acicularis* (L.) Roemer & Schultes—Rare but widespread in wet meadows and on shores of small inland ponds (*5987*).
*E. caribaea* (Rottb.) S.F. Blake (*E. geniculata*)—Occasional but widespread on beach strands and sandy pond shores between Gravelly Bay and the tip of the Point (*5304, 8382*).
*E. elliptica* Kunth—Abundant and widespread in wet sedge meadows (*5974*).
*E. engelmannii* Steudel—Not seen during this survey (*Ball 86404*, TRTE).
*E. equisetoides* (Elliott) Torrey—Very rare and local in an emergent wetland along a pond shore near Gravelly Bay (*8379*).
*E. erythropoda* Steudel (*E. calva*)—Occasional and scattered in wet meadows (*6096*).
*E. intermedia* Schultes—Rare but widespread on beach strands (*5269*).
*E. olivacea* Torrey—Occasional but widespread on beach strands and in sandy, wet meadows (*5270, 5305*).
*E. quadrangulata* (Michaux) Roemer & Schultes—Occasional and scattered in emergent wetlands of inland pools (*5313*).
*E. quinqueflora* (Hartman) Sw. (*E. pauciflora*)—Occasional but widespread in wet sedge meadows (*5303, 5673*). (Walters 1980).
*E. smallii* Britton (*E. palustris* of authors)—Occasional but widespread in emergent wetlands and wet meadows (*5973*).
*Eriophorum gracile* Koch—Rare and local in floating sedge mats near Gravelly Bay (*5621*).
*Fimbristylis autumnalis* (L.) Roemer & Schultes—Occasional and scattered on beach strands and sandy pond shores between Gravelly Bay and the tip of the Point (*8383*).
*Rhynchospora alba* (L.) Vahl—Rare and local in floating sedge mats in the vicinity of Gravelly Bay (*6098*).
*R. capillacea* Torrey—Occasional but widespread in wet sedge meadows (*5307*).
*Scirpus acutus* Bigelow, hardstem bulrush—Abundant and widespread in emergent wetlands and wet sedge meadows (*6002*).
*S. atrovirens* Willd.—Rare and local in wet meadows and openings in Tamarack-White Cedar swamp (*6126*).
*S. cyperinus* (L.) Kunth, wool-grass—Occasional and scattered in emergent wetlands and wet meadows (*5257*).
*S. fluviatilis* (Torrey) A. Gray, river bulrush—Rare and local in emergent wetlands (*5663*).
*S. pungens* Vahl (*S. americanus* of authors), threesquare—Abundant and widespread in

emergent wetlands and wet sedge meadows and on beach strands (*6154*). (Schuyler 1974).

*S. smithii* A. Gray—Rare but widespread on beach strands (*5350, 8384*).

*S. subterminalis* Torrey, swaying rush—Rare but scattered in submerged and floating-leaved aquatic communities of shallow inland pools (*5364*).

*S. validus* Vahl, softstem bulrush—Occasional and scattered in emergent wetlands and wet meadows (*5959*).

*Scleria verticillata* Willd., nut-rush—Occasional but widespread in wet sedge meadows; rarely in dense stands over local areas (*5326*).

ARACEAE

*Calla palustris* L., wild calla—Rare and local in Tamarack-White Cedar swamp (*5628*).

*Peltandra virginica* (L.) Schott & Endl., arrow-arum—Not seen during this survey (*Oldham 8473*, MICH).

LEMNACEAE

*Lemna minor* L., duckweed—Abundant and widespread, floating on shallow water (*5470*).

*L. trisulca* L., star duckweed—Occasional but widespread in shallow water (*5242*).

*Spirodela polyrhiza* (L.) Schleiden, greater duckweed—Rare and scattered, floating on shallow water (*5611*).

*Wolffia borealis* (Engelm.) Landolt (*W. punctata*)—Rare and scattered, floating on shallow water (*6062*). (Landolt & Wildi 1977).

*W. columbiana* Karsten—Occasional and scattered, floating on shallow water (*5279*).

PONTEDERIACEAE

*Heteranthera dubia* (Jacq.) MacMillan, water star-grass—Occasional but widespread in various submerged aquatic communities (*5966*).

*Pontederia cordata* L., pickerel-weed—Occasional but widespread in emergent wetlands, locally forming large stands (*5969*).

JUNCACEAE

*Juncus acuminatus* Michaux—Not seen during this survey (*Landon* in 1949, OAC).

*J. alpinoarticulatus* Chaix (*J. alpinus*)—Occasional but widespread on beach strands and in wet meadows (*6155*). (Hämet-Ahti 1980b).

*J. articulatus* L.—Occasional and scattered on beach strands and in wet meadows (*5309*).

*J. balticus* Willd.—Abundant and widespread on beach strands and low dunes and in wet meadows (*6153*).

*J. brachycephalus* (Engelm.) Buchenau—Occasional and local in emergent wetlands and wet meadows (*5259*).

*J. bufonius* L., toad rush—Occasional but widespread on beach strands and in wet meadows and weedy habitats (*6151*).

*J. canadensis* La Harpe—Rare but widespread in wet meadows and emergent wetlands (*5261, 5293*).

*J. dudleyi* Wieg.—Occasional and scattered in weedy habitats and wet meadows (*5900*).

*J. effusus* L., soft rush—Occasional and scattered in wet meadows and emergent wetlands (*6040*). Our specimen is referrable to *J. pylaei* La Harpe (*J. effusus* var. *pylaei* (La Harpe) Fern. & Wieg.) in Hämet-Ahti (1980a).

*J. nodosus* L.—Occasional and local in wet meadows and on beach strands (*5260, 6085a*).

*J. tenuis* Willd., path rush—Occasional and scattered in wet meadows and weedy habitats (*6008*).

*J. torreyi* Cov.—Occasional but widespread in wet meadows (*6004*).

LILIACEAE

*Allium canadense* L., wild garlic—Occasional at one site, in wet thickets under Bur Oak on Ryerson's Island (*6063*).

**Asparagus officinalis* L., garden asparagus—Rare but widespread in Oak savanna and Cottonwood-Red Cedar savanna (*5605*).

*Maianthemum canadense* Desf., Canada mayflower—Occasional but widespread in Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, and Tamarack-White Cedar swamp (*5464*).

**Ornithogalum umbellatum* L., star-of-bethlehem—Rare at one site, in dry thickets under Cottonwoods on Ryerson's Island (*5522*).

*Polygonatum pubescens* (Willd.) Pursh, solomon-seal—Rare and local in Red Oak-Sugar Maple forest (*5479*).

*Smilacina stellata* (L.) Desf., false solomon-seal—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna, White Pine-White Cedar-Red Cedar forest, Oak savanna, and Red Oak-Sugar Maple forest (*5445*).

*Smilax hispida* Torrey, bristly greenbrier—Rare in shrubby Cottonwood savanna on Ryerson's Island (*Sutherland 7527*, MICH).

*Tofieldia glutinosa* (Michaux) Pers., false asphodel—Occasional and scattered in wet sedge meadows near Gravelly Bay (*5992*).

IRIDACEAE

**Iris pseudacorus* L., yellow flag—Rare in an emergent wetland at one site on the north side of Courtright Ridge (*5662*).

*I. virginica* L., southern blue flag—Occasional and scattered in wet meadows and emergent wetlands (*5390, 5587*).

*Sisyrinchium montanum* E. Greene, blue-eyed-grass—Rare and scattered in wet sedge meadows (*5452*).

ORCHIDACEAE

*Calopogon tuberosus* (L.) BSP. (*C. pulchellus*), grass-pink—Occasional and scattered in wet sedge meadows between Gravelly Bay and the tip of the Point (*6012*).

*Corallorhiza odontorhiza* (Willd.) Nutt., fall coral-root—Rare at one site in dry White Pine forest near Gravelly Bay (*5314*).

*C. trifida* Chatel., early coral-root—Rare and local in Tamarack- White Cedar swamp near Gravelly Bay (*5444*).

*Cypripedium calceolus* L., yellow lady slipper—Rare and local in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*5588a*).

**Epipactis helleborine* (L.) Crantz, helleborine—Rare but widespread in White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*5977*).

*Goodyera pubescens* (Willd.) R. Br., downy rattlesnake-plantain—Rare and local on mossy hummocks in Red Oak-Sugar Maple forest (*6104*).

*Liparis loeselii* (L.) Rich., bog twayblade—Rare but widespread in wet sedge meadows and Tamarack-White Cedar swamp (*5593*).

*Platanthera hyperborea* (L.) Lindley (*Habenaria hyperborea*), tall northern bog orchid—Rare and scattered in Tamarack-White Cedar swamp (*5986*).

*Pogonia ophioglossoides* (L.) Juss., rose pogonia—Rare at one site in a wet sedge meadow near Gravelly Bay (*6005*).

*Spiranthes cernua* (L.) Rich., nodding ladies'-tresses—Occasional but widespread in wet sedge meadows (*5262, 5329*).

*S. lucida* (H.H. Eaton) O. Ames, shining ladies'-tresses—Rare and local in sandy, wet sedge meadows (*5680*).

*S. magnicamporum* Sheviak, great plains ladies'-tresses—Rare and local in wet sedge meadows (*Catling* in 1976, TRT).

*S. romanzoffiana* Cham., hooded ladies'-tresses—Rare and local in wet sedge meadows (*6020*).

## DICOTYLEDONS

### SALICACEAE

**Populus alba* L., white poplar—Rare and local in Cottonwood-Red Cedar savanna and on low dunes (*5468a*).

*P. deltoides* Marshall, cottonwood—Abundant and widespread, a dominant of Cottonwood-Red Cedar savanna, occasional in other communities and present as abundant seedlings on the beach strand (*5525*).

*P. ×jackii* Sarg. (*P. balsamifera* × *P. deltoides*)—Not seen during this survey (*Lindsay & Macdonald 1093, 1103* in 1976, CAN). *P. balsamifera* is not known from the Point. Det. J.E. Eckenwalder.

*P. tremuloides* Michaux, quaking aspen—Rare and local in edges of wet meadows and on low dunes (*5397*).

**Salix alba* L., white willow—Rare and local on low dunes and in edges of wet meadows (*5250, 5503*). Det. G.W. Argus.

*S. amygdaloides* Andersson, peach-leaved willow—Rare and local in wet meadows (*5543*). Det. G.W. Argus.

*S. bebbiana* Sarg., Bebb's willow—Rare and local in wet meadows (*5542*). Det. G.W. Argus.

**S. caprea* L., goat willow—Rare and local in weedy habitats near the base of the Point (*5549*). Det G.W. Argus.

*S. cordata* L. (incl. *S. syrticola*), heartleaf willow—Not seen during this survey (*Falls & Klawe 734* in 1951, TRT). Det. G.W. Argus.

*S. discolor* Muhlenb., pussy willow—Rare and local in wet meadows (*5602, 5603*). Det. G.W. Argus.

*S. eriocephala* Michaux (*S. rigida*), Missouri willow—Occasional and scattered on low dunes and in wet meadows (*5246, 5541, 5544*). (Argus 1980). Det. G.W. Argus.

*S. exigua* Nutt. (incl. *S. interior*), sandbar willow—Occasional and scattered on low dunes and along edges of wet meadows (*5505, 5593*). Det. G.W. Argus.

*S. myricoides* Muhlenb. (*S. glaucophylloides*), blueleaf willow—Occasional but widespread on dry dunes; No. *5535* is the striking, silver-hairy var. *albovestita* (C. Ball) Dorn (*5338, 5394, 5535*). (Dorn 1976). Det G.W. Argus.

*S. nigra* L., black willow—Occasional and scattered on low dunes (*5247, 5249, 5400*). Det. G.W. Argus.

*S. pedicellaris* Pursh, bog willow—Rare; a single shrub in a floating sedge mat near Gravelly Bay (*5626*). Det. G.W. Argus.

**S. purpurea* L., basket willow—Rare and local on low dunes (*5248*). Det. G.W. Argus.

**S. ×rubens* Schrank (*S. alba* × *S. fragilis*)—Rare and local in depressions in Oak savanna and on low dunes (*5502*). *S. fragilis* is not known from the Point. Det. G.W. Argus.

### JUGLANDACEAE

*Carya ovata* (Mill.) K. Koch, shagbark hickory—Rare and local in Oak savanna on Courtright Ridge (*5508*).

*Juglans cinerea* L., butternut—Rare and local in Oak savanna on Courtright Ridge (*5657*).

### BETULACEAE

**Alnus glutinosa* (L.) Gaertner, black alder—Rare and local in wet, weedy habitats near the base of the Point (*5540*).

*Betula papyrifera* Marshall, white birch—Abundant and widespread; in Tamarack-White Cedar swamp, also frequent in White Pine-White Cedar-Red Cedar forest, locally forming small, pure stands (*5630*).

*Carpinus caroliniana* Walter, blue-beech—Rare and local in Oak savanna and Red Oak-Sugar Maple forest (*5658*).

*Ostrya virginana* (Miller) K. Koch, hop-hornbeam—Occasional and scattered in Oak savanna and Red Oak-Sugar Maple forest (*5657*).

FAGACEAE

*Quercus alba* L., white oak—Occasional but widespread in Oak savanna and Red Oak-Sugar Maple forest (*6116*).

*Q.* ×*deamii* Trel. (*Q. macrocarpa* × *Q. muehlenbergii*)—Rare; a single tree in Oak savanna on the east end of Courtright Ridge (*6038*). Det. W.H. Wagner, Jr.

*Q. macrocarpa* Michaux, bur oak—Occasional and local in Oak savanna on low dunes, most frequent on Bluff Point and Ryerson's Island (*6082*).

*Q. muehlenbergii* Engelm., chinquapin oak—Occasional and local in Oak savanna (*5368*).

*Q. rubra* L., red oak—Abundant and widespread; the major dominant of Oak savanna and an important component of Red Oak-Sugar Maple forest; also present in White Pine-White Cedar-Red Cedar forest (*5660*).

ULMACEAE

*Celtis occidentalis* L., hackberry—Occasional and local, most frequent on Courtright and Squires Ridges in Oak savanna but occurring rarely to within 4 km of the tip (*5500, 5569*).

*Ulmus americana* L., American elm—Rare and local in Oak savanna (*5485, 6089*).

MORACEAE

**Humulus lupulus* L., hop—Not seen during this survey (*Heffernan* in 1978, DAO).

URTICACEAE

*Boehmeria cylindrica* (L.) Sw., false nettle—Abundant but scattered in emergent wetlands and Tamarack-White Cedar swamp (*5958*).

*Parietaria pensylvanica* Willd., pellitory—Occasional and scattered in Red Oak-Sugar Maple forest and Oak savanna (*5376*).

*Pilea fontana* (Lunell) Rydb., clearweed—Occasional and scattered on hummocks in emergent wetlands and in floating sedge mats (*5256*).

*Urtica dioica* L. subsp. *gracilis* (Aiton) Selander, stinging nettle—Occasional and local in weedy habitats, depressions in Oak savanna, and wet meadows (*6064*). (Woodland 1982).

POLYGONACEAE

**Fagopyrum esculentum* Moench, buckwheat—Not seen during this survey (*Oldham 8537*, MICH).

*Polygonum amphibium* L., water smartweed—Occasional but widespread in wet meadows, emergent wetlands, and various submerged and floating-leaved aquatic communities; No. *5241* is var. *emersum* Michaux (*P. coccineum*) and No. 5278 is var. *stipulaceum* N. Coleman (*5241, 5278*).

**P. arenastrum* Boreau, knotweed—Occasional and scattered in weedy habitats (*6138*). Det. D. Katz-Downie.

**P. convolvulus* L., black-bindweed—Occasional and scattered in weedy habitats (*6080*).

*P. lapathifolium* L., pale smartweed—Abundant and widespread on beach strands and in wet meadows and weedy habitats (*5388*).

*P. pensylvanicum* L., Pennsylvania smartweed—Occasional and scattered on beach strands and in wet meadows and weedy habitats (*5398*).

**P. persicaria* L., lady's thumb—Occasional and scattered on beach strands and in weedy habitats (*6136*).

*P. punctatum* Elliott, water smartweed—Occasional and scattered in emergent wetlands (*5233, 6084*).

*P. sagittatum* L., tear-thumb—Rare and local in small, wet depressions in Red Oak-Sugar Maple forest (*5373*).

*P. scandens* L., climbing false buckwheat—Rare at one site in Oak savanna on Squires Ridge (*5387*).

*P. virginianum* L. (*Tovara virginiana*), jumpseed—Rare in moist Bur Oak savanna on Ryerson's Island (*6054*).

***Rumex acetosella* L., sheep sorrel—Abundant and widespread in Oak savanna and weedy habitats (*5468*).
***R. crispus* L., sour dock—Rare and local in Oak savanna, White Pine-White Cedar-Red Cedar forest, and weedy habitats (*Falls & Klawe 444*, TRT).
*R. orbiculatus* A. Gray, great water dock—Occasional and scattered in emergent wetlands (*5267*).
*R. verticillatus* L., water dock—Not seen during this survey (*Ashenden 143*, MICH).

CHENOPODIACEAE

***Atriplex patula* L., spearscale—Rare and local in weedy habitats (*6418*).
***Chenopodium album* L., lambs-quarters—Occasional and scattered in weedy habitats (*6415*). Det. I.J. Bassett & C.W. Crompton.
*C. foggii* Wahl, goosefoot—Occasional but widespread in Red Oak-Sugar Maple forest, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*5282, 5339, 5371*). (Bassett & Crompton 1982). Det. I.J. Bassett & C.W. Crompton.
*C. gigantospermum* Aellen, goosefoot—Rare and scattered on beach strands and in Oak savanna and weedy habitats (*6140*). (Bassett & Crompton 1982). Det. I.J. Bassett & C.W. Crompton.
*Corispermum hyssopifolium* L., bugseed—Occasional but widespread on dry dunes and in Cottonwood-Red Cedar savanna (*5255*).
***Cycloloma atriplicifolium* (Sprengel) J. Coulter, winged pigweed—Occasional and scattered on beach strands and in weedy habitats (*6011*).
***Salsola pestifer* Nelson (*S. kali* var. *tenuifolia*), Russian thistle—Occasional but widespread on beach strands and dry dunes and in weedy habitats (*6024*). (Crompton & Bassett 1985).

AMARANTHACEAE

***Amaranthus albus* L., amaranth—Rare and scattered in weedy habitats (*6137*).
*A. retroflexus* L., green amaranth—Occasional and scattered in weedy habitats (*6139*).

PHYTOLACCACEAE

*Phytolacca americana* L., pokeweed—Occasional and scattered in Red Oak-Sugar Maple forest and Oak savanna (*5374*).

PORTULACACEAE

*Portulaca oleracea* L., purslane—Occasional and scattered in weedy habitats (*6142*).

CARYOPHYLLACEAE

***Arenaria serpyllifolia* L., sandwort—Abundant and widespread in weedy habitats and Oak savanna and on dry dunes (*5442*). Det. R.K. Rabeler.
***Cerastium fontanum* Baumg. (*C. vulgatum*), mouse-ear chickweed—Occasional and scattered in weedy habitats and Oak savanna (*5300*).
*C. nutans* Raf., nodding chickweed—Rare and local on steep, north-facing slopes in Red Oak-Sugar Maple forest on Squires Ridge (*5471*). Det. R.K. Rabeler.
***C. semidecandrum* L., chickweed—Rare and local in weedy habitats near the base of the Point (*5537*). Det. R.K. Rabeler.
*Moehringia lateriflora* (L.) Fenzl (*Arenaria lateriflora*), sandwort—Occasional but widespread in Oak savanna, Red Oak-Sugar Maple forest, and White Pine-White Cedar-Red Cedar forest (*5439*). Det. R.K. Rabeler.
***Saponaria officinalis* L., bouncing bet—Rare and local in weedy habitats (*6130*). Det. R.K. Rabeler.
*Silene antirrhina* L., sleepy catchfly—Occasional but widespread on dry dunes and in Oak savanna (*5607*). Det. R.K. Rabeler.
***S. latifolia* Poiret (*S. alba, S. pratensis, Lychnis alba*), white campion—Occasional and scattered in weedy habitats (*5545*). (Greuter & Burdet 1982). Det. R.K. Rabeler.
*Stellaria longifolia* Willd., long-leaved chickweed—Rare in wet grass meadows on Ryerson's Island (*6051*). Det. R.K. Rabeler.
***S. media* (L.) Villars, common chickweed—Abundant and widespread on dry dunes and

FIGURE 26. American Lotus (*Nelumbo lutea*) growing with Water-Milfoil (*Myriophyllum heterophyllum*) and Water Star-Grass (*Heteranthera dubia*) near Big Rice Bay. The background is formed by Hybrid Cat-tail (*Typha ×glauca*) marsh. Aug. 3, 1980. Previously published as the cover photo for Michigan Bot. Vol. 21(4), 1982.

in weedy habitats, Oak savanna, Red Oak-Sugar Maple forest, and White Pine-White Cedar-Red Cedar forest (*5472*). Det. R.K. Rabeler.

CERATOPHYLLACEAE

*Ceratophyllum demersum* L., coontail—Abundant and widespread in emergent wetlands and various submerged or floating-leaved aquatic communities; often a dominant (*5232*).

NYMPHACEAE

*Brasenia schreberi* J. Gmelin, water-shield—Abundant but local in floating-leaved aquatic communities; present in a few ponds in the vicinity of Gravelly Bay where it is a major dominant (*5321, 5618*).

*Nelumbo lutea* (Willd.) Pers., American lotus—One large colony in Big Rice Bay (*6046*). This species has been known at this site since 1914 (*Howitt* in 1914, OAC). Figure 26.

*Nuphar advena* (Aiton) Aiton f., spatterdock—Occasional and local in floating-leaved aquatic communities (*5521*).

*N. variegata* Durand, bullhead-lily—Abundant and widespread in various submerged or floating-leaved aquatic communities (*5589*).

*Nymphaea odorata* Aiton (incl. *N. tuberosa*), fragrant water-lily—Abundant and widespread in various submerged or floating-leaved aquatic communities (*6048*).

MAGNOLIACEAE

*Liriodendron tulipifera* L., tulip-tree—Rare and local in Oak savanna on Squires Ridge (*5488*).

RANUNCULACEAE

*Actaea rubra* (Aiton) Willd., red baneberry—Not seen during this survey (*Ralph* in 1978, DAO).

*Anemone canadensis* L., Canada anemone—Rare and local in wet meadows near the base of the Point (*6405*).

*A. quinquefolia* L., wood anemone—Rare and local in Red Oak-Sugar Maple forest (*5482*).

*A. virginiana* L. (incl. *A. riparia*), thimbleweed—Occasional and local on low dunes and in Cottonwood savanna near the base of the Point (*6158*).

*Aquilegia canadensis* L., wild columbine—Occasional and scattered in Red Oak-Sugar Maple forest, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*5491*).

*Clematis virginiana* L., virgin's bower—Not seen during this survey (*Falls & Klawe 777* in 1951, TRT).

*Ranunculus abortivus* L., small-flowered buttercup—Occasional and local in Red Oak-Sugar Maple forest (*5481*).

**R. acris* L., common buttercup—Occasional and local in weedy habitats (*5563*).

*R. hispidus* Michaux var. *caricetorum* (E. Greene) T. Duncan (*R. septentrionalis*), swamp buttercup—Occasional and local in wet sedge meadows and emergent wetlands (*5551*). (Duncan 1980).

*R. longirostris* Godron, white water crowfoot—Occasional but widespread in various submerged aquatic communities (*5324, 5510*).

*R. sceleratus* L., cursed crowfoot—Rare and local in weedy habitats (*5548*).

*Thalictrum pubescens* Pursh (*T. polygamum*), purple meadow-rue—Not seen during this survey (*Ashenden 88*, MICH). (Boivin 1957).

BERBERIDACEAE

**Berberis thunbergii* DC., Japanese barberry—Rare and local in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*8380*).

**B. vulgaris* L., common barberry—Rare; a single shrub at one site near the south beach in White Pine-White Cedar-Red Cedar forest (*5044*).

*Podophyllum peltatum* L., may-apple—Rare and local in Oak savanna on Courtright Ridge (*5514*).

LAURACEAE

*Sassafras albidum* (Nutt.) Nees, sassafras—Abundant but scattered in Red Oak-Sugar Maple forest and Oak savanna (*5477*).

PAPAVERACEAE

**Chelidonium majus* L., celandine—Occasional at one site in a weedy habitat near a cabin on Courtright Ridge (*5517*).

BRASSICACEAE

**Alyssum alyssoides* (L.) L., pale alyssum—Rare and scattered on dry dunes and in weedy habitats (*5533*).

**Arabidopsis thaliana* (L.) Heynh., mouse-ear cress—Occasional and scattered on dry dunes and in Oak savanna and weedy habitats (*5466*).

*Arabis canadensis* L., sickle-pod—Rare and local in Red Oak-Sugar Maple forest on Squires Ridge (*6111*).

*A. drummondii* A. Gray—Rare but scattered in Oak savanna (*5617*).

*A. glabra* (L.) Bernh., tower mustard—Occasional and scattered in Oak savanna (*5615*).

*A. laevigata* (Muhlenb.) Poiret—Rare in thickets under Cottonwood savanna on Ryerson's Island (*6056*).

*A. lyrata* L., sand cress—Abundant and widespread on dry dunes and in Cottonwood-

Red Cedar savanna, Oak savanna, and openings in White Pine-White Cedar-Red Cedar forest (*5519*).

**Barbarea vulgaris* R. Br., yellow rocket—Occasional and scattered in weedy habitats (*5546*).

**Berteroa incana* (L.) DC., hoary alyssum—Rare and local in weedy habitats (*5566*).

*Cakile edentula* (Bigelow) Hook., sea rocket—Occasional but widespread on beach strands and dry dunes (*6025*).

**Camelina microcarpa* DC., false flax—Rare and local in weedy habitats (*5652*).

**Capsella bursa-pastoris* (L.) Medikus, shepherd's-purse—Occasional and scattered in weedy habitats (*5484*).

**Cardamine hirsuta* L., bitter cress—Occasional and local in Oak savanna (*5438*).

*C. pensylvanica* Willd., Pennsylvania bitter cress—Occasional and scattered in wet meadows, Tamarack-White Cedar swamp, and wet depressions in Red Oak-Sugar Maple forest (*5379, 6065, 6085*).

*C. pratensis* L., cuckoo-flower—Rare at one site in a wet opening in a Tamarack-White Cedar swamp near Gravelly Bay (*5463*).

*Descurania pinnata* (Walter) Britton, tansy-mustard—Occasional and scattered on low dunes on Ryerson's Island (*5523*).

**D. sophia* (L.) Prantl—Rare and local in weedy habitats (*6149*).

**Diplotaxis tenuifolia* (L.) DC., wall rocket—Occasional and local in weedy habitats and on dry dunes (*Pringle 284*, HAM).

**Erophila verna* (L.) Besser, whitlow-grass—Not seen during this survey (*Sutherland 6835*, MICH).

**Erucastrum gallicum* (Willd.) O. Schulz, dog mustard—Occasional and local in weedy habitats (*6419*).

*Erysimum cheiranthoides* L., wormseed mustard—Occasional and scattered in weedy habitats and Oak savanna (*5538*).

**Hesperis matronalis* L., dame's rocket—Rare and local in moist, weedy habitats (*5561*).

**Lepidium campestre* (L.) R. Br., field pepper-grass—Occasional and scattered in weedy habitats and Oak savanna (*5490*).

**L. densiflorum* Schrader, pepper-grass—Occasional and local in weedy habitats, Oak savanna, and Cottonwood-Red Cedar savanna (*5315*).

*L. virginicum* L., poor-man's pepper-grass—Rare and local in weedy habitats and Oak savanna (*5650*).

*Rorippa palustris* (L.) Besser (*R. islandica*), yellow cress—Occasional and scattered on beach strands and in wet meadows and emergent wetlands (*5392*). (Stuckey 1972).

**Sinapis arvensis* L. (*Brassica kaber*), wild mustard—Rare and local in weedy habitats (*5683*).

**Sisymbrium altissimum* L., tumble mustard—Occasional and scattered in weedy habitats and Oak savanna (*5380, 5653*).

**S. officinale* (L.) Scop., hedge mustard—Rare and local in weedy habitats and Oak savanna (*5649*).

**Thlaspi arvense* L., penny cress—Rare and local in weedy habitats (*5568*).

CAPPARACEAE

*Polanisia dodecandra* (L.) DC., clammy-weed—Occasional but widespread on beach strands, dry dunes, and in blowouts and thinly vegetated, sandy openings in Oak savanna and White Pine-White Cedar-Red Cedar forest (*5317*).

DROSERACEAE

*Drosera rotundifolia* L., sundew—Rare and local on Sphagnum hummocks in floating sedge mats (*5365*).

CRASSULACEAE

**Sedum acre* L., mossy stonecrop—Occasional and scattered on dry dunes and in Cottonwood-Red Cedar savanna; mostly near present or former habitation (*5596*).

SAXIFRAGACEAE

*Parnassia glauca* Raf., grass-of-parnassus—Occasional and scattered, although very locally abundant, in wet sedge meadows (*Bahr B172/64*, HAM).

*Ribes americanum* Miller, wild black currant—Rare and local in open Cottonwood forest near the base of the Point (*5689*).

PLATANACEAE

*Platanus occidentalis* L., sycamore—Rare but widespread in Oak savanna; most frequent on Ryerson's Island and Bluff Point (*5524*).

ROSACEAE

*Amelanchier arborea* (Michaux f.) Fern., downy juneberry—Rare but widespread in Oak savanna; all individuals seen were tree-like. A tree on Squires Ridge was 29 cm in diameter at breast height (*5287, 5489*). Det. S.M. McKay.

*A. laevis* Wieg., smooth juneberry—Not seen during this survey (*Soper* in 1951, TRT). Det. S.M. McKay.

*Crataegus brainerdii* Sarg.—Rare and local in Oak savanna on Courtright Ridge (*5664*). Det. J.B. Phipps.

*C. pedicellata* Sarg.—Occasional and scattered in Oak savanna (*5266, 5509, 6086*). Det. J.B. Phipps.

*C. pringlei* Sarg.—Rare and local in Oak savanna (*5520*). Det. J.B. Phipps.

*C. punctata* Jacq., dotted hawthorn—Occasional but widespread in Oak savanna and Red Oak-Sugar Maple forest (*5651, 5655*). Det. J.B. Phipps.

*C. succulenta* Link—Rare and scattered in Oak savanna (*5656, 6087*). Det. J.B. Phipps.

*Fragaria virginiana* Miller, wild strawberry—Occasional and widespread in Oak savanna, Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, Tamarack-White Cedar swamp, and wet meadows (*5536*).

*Geum canadense* Jacq., white avens—Rare and local in Oak savanna on Ryerson's Island (*6057*).

**Malus domestica* Borkh., apple—Rare and local in Oak savanna on Squires Ridge (*5478*).

*Physocarpus opulifolius* (L.) Maxim., ninebark—Rare in open Scots Pine plantation near the base of the Point (*5686*).

*Potentilla anserina* L., silverweed—Occasional but widespread on beach strands and in wet meadows (*5659*).

**P. argentea* L., silvery cinquefoil—Occasional and local in weedy habitats (*6400*).

*P. norvegica* L., rough cinquefoil—Occasional and local on beach strands and in wet meadows, Tamarack-White Cedar swamp, and weedy habitats (*6006*).

*P. palustris* (L.) Scop., marsh cinquefoil—Occasional and scattered in emergent wetlands and wet meadows (*5281, 5619*).

*P. paradoxa* Nutt., bushy cinquefoil—Rare and local on beach strands at the base of the Point and along the north beach near Gravelly Bay (*Oldham 7584*, MICH).

*Prunus pumila* L., sand cherry—Rare; a few shrubs on low dunes near the base of the Point in Long Point Provincial Park (*5534*).

*P. serotina* Ehrh., black cherry—Occasional but widespread in Oak savanna and Red Oak-Sugar Maple forest (*5669*).

*P. virginiana* L., choke cherry—Occasional but widespread in Oak savanna, forming dense thickets on Ryerson's Island but elsewhere mostly tree-like; a tree on a ridge 0.8 km east of Gravelly Bay was 29 cm in diameter at breast height (*5526*).

*Rosa blanda* Aiton, wild rose—Rare and local on dry dunes (*5674*).

**R. multiflora* Murray, multiflora rose—Rare and local in weedy habitats near the base of the Point (*8372*).

*R. palustris* Marshall, swamp rose—Rare and local in emergent wetlands and Tamarack-White Cedar swamp (*5976*).

**R. rubiginosa* L. (*R. eglanteria*), sweetbrier—Occasional and scattered in Oak savanna and openings in White Pine-White Cedar-Red Cedar forest; essentially the only true shrub in the Oak savanna (*5994*).

*Rubus allegheniensis* Porter, common blackberry—Not seen during this survey (*Mohr 72*, DAO).

*R. occidentalis* L., black raspberry—Rare and local in open Cottonwood savanna and weedy habitats near the base of the Point (*5690*).

*R. odoratus* L., flowering raspberry—Not seen during this survey (*Falls & Klawe 446* in 1951, TRT).

*R. strigosus* Michaux, wild red raspberry—Rare and local in White Pine-White Cedar-Red Cedar forest and weedy habitats (*5575*).

*Spiraea alba* Duroi (incl. *S. latifolia*), meadowsweet—Occasional but widespread in wet meadows and emergent wetlands (*5349, 6401*).

FABACEAE

*Amphicarpaea bracteata* (L.) Fern., hog-peanut—Occasional but widespread in wet meadows, Tamarack-White Cedar swamp, and wet depressions in Red Oak-Sugar Maple forest and Oak savanna (*5391*).

*Apios americana* Medikus, groundnut—Rare and scattered in wet meadows (*6050*).

*Astragalus canadensis* L., Canada milk vetch—Not seen during this survey (*Senn & Soper 640* in 1938, TRT).

*Desmodium canadense* (L.) DC., showy tick-trefoil—Occasional and local near the base of the Point on low dunes and in wet meadows (*6157*).

*Lathyrus japonicus* Willd., beach pea—Occasional but widespread on beach strands and dry dunes (*5609*).

*L. palustris* L., marsh pea—Occasional but widespread in wet meadows and emergent wetlands (*5601*).

**Lotus corniculata* L., birdfoot trefoil—Rare and scattered in weedy habitats (*5679*).

**Medicago lupulina* L., black medick—Occasional and scattered in weedy habitats and Oak savanna (*6103*).

**M. sativa* L., alfalfa—Rare and scattered in weedy habitats (*5553*).

**Melilotus alba* Medikus, white sweet-clover—Occasional but widespread in weedy habitats, Oak savanna, Cottonwood-Red Cedar savanna, and on dry dunes (*5678*).

**M. officinalis* (L.) Pallas, yellow sweet-clover—Not seen during this survey (*Johnson* in 1972, TRT).

*Strophostyles helvula* (L.) Elliott, wild bean—Occasional but widespread on beach strands, dry dunes, and in weedy habitats (*6145*).

**Trifolium hybridum* L., alsike clover—Rare and local in weedy habitats (*6234*).

**T. pratense* L., red clover—Occasional and local in weedy habitats (*6143*).

**T. repens* L., white clover—Occasional and local in weedy habitats (*5560*).

**Vicia villosa* Roth, hairy vetch—Rare and local in weedy habitats (*6424*).

OXALIDACEAE

*Oxalis fontana* Bunge (*O. europaea*), wood sorrel—Occasional but widespread in weedy habitats, Oak savanna, and Red Oak-Sugar Maple forest (*5369*). (Lourtieg 1979).

GERANIACEAE

*Geranium maculatum* L., wild geranium—Not seen during this survey (*Johnstone* in 1959, MTMG).

*G. robertianum* L., herb robert—Occasional and local in Red Oak-Sugar Maple forest and Oak savanna (*5515*).

LINACEAE

*Linum medium* (Planchon) Britton var. *texanum* (Planchon) Fern., yellow flax—Occasional and scattered in wet meadows between Gravelly Bay and the tip of the Point (*5301, 5332*).

RUTACEAE

*Ptelea trifoliata* L., hop tree—Rare; a solitary large shrub on dry dunes near the south beach opposite the Little Creek Ridges, about 6 1/2 km west of Gravelly Bay (*5258*).

*Zanthoxylum americanum* Miller, prickly-ash — Rare and local in Red Oak-Sugar Maple forest on Squires Ridge (*8376*).

POLYGALACEAE

*Polygala paucifolia* Willd., fringed polygala — Rare and local in White Pine-White Cedar-Red Cedar forest (*5635*).

EUPHORBIACEAE

**Euphorbia esula* L., leafy spurge — Occasional and local in Oak savanna on Courtright Ridge (*5506*).

*E. glyptosperma* Engelm. — Occasional and scattered in weedy habitats, in Cottonwood-Red Cedar savanna, and on dry dunes (*5383*).

**E. maculata* L., eyebane — Occasional and local in weedy habitats (*5403*).

**E. platyphylla* L. — Not seen during this survey (*Hamilton* in 1899, OAC).

*E. polygonifolia* L., seaside spurge — Occasional but widespread on beach strands and dry dunes and in Cottonwood-Red Cedar savanna and blowouts in Oak savanna (*6022*).

**E. vermiculata* Raf. — Rare and local in weedy habitats (*5244a*).

ANACARDIACEAE

*Rhus typhina* L., staghorn sumac — Rare and local on low dunes and in Cottonwood savanna and Red Oak-Sugar Maple forest; most frequent on Ryerson's Island (*5527*).

*Toxicodendron radicans* (L.) Kuntze, poison-ivy — Rare and local in weedy habitats and Cottonwood-Red Cedar savanna and on dry dunes; both subsp. *radicans* and subsp. *rydbergii* (Rydb.) Löve & Löve occur on the Point (*Oldham 4180*, CAN — subsp. *rydbergii*). McNeill (1981).

AQUIFOLIACEAE

*Ilex verticillata* (L.) A. Gray, winterberry — Not seen during this survey (*Falls & Klawe 593* in 1951, TRT).

CELASTRACEAE

*Celastrus scandens* L., American bittersweet — Rare but widespread in Cottonwood-Red Cedar savanna, White Pine-White Cedar-Red Cedar forest, Oak savanna, Red Oak-Sugar Maple forest, and on dry dunes; a vine climbing a White Cedar south of Gravelly Bay measured 11 cm in diameter at 3 dm above the ground (*5687*).

ACERACEAE

*Acer negundo* L., Manitoba maple — Occasional but widespread in Oak savanna, White Pine-White Cedar-Red Cedar forest, and weedy habitats (*5467*).

*A. rubrum* L., red maple — Abundant and widespread in Red Oak-Sugar Maple forest, Oak savanna, and Tamarack-White Cedar swamp; very locally a dominant (*5469*).

*A. saccharinum* L., silver maple — Rare and local in weedy habitats near the base of the point (*6129*).

*A. saccharum* Marshall, sugar maple — Abundant and widespread; a dominant of Red Oak-Sugar Maple forest and also locally present in Oak savanna and White Pine-White Cedar-Red Cedar forest (*6081*).

BALSAMINACEAE

*Impatiens capensis* Meerb., spotted touch-me-not — Occasional but widespread in wet meadows, various emergent wetlands, and Tamarack-White Cedar swamp (*6124*).

RHAMNACEAE

**Rhamnus cathartica* L., common buckthorn — Rare; a single shrub in Cottonwood savanna near the base of the Point (*6412*).

VITACEAE

*Parthenocissus inserta* (A. Kerner) Fritsch (*P. vitacea*), thicket creeper — Rare but widespread in weedy habitats, White Pine-White Cedar-Red Cedar forest, and Oak savanna (*6159*).

*P. quinquefolia* (L.) Planchon, virginia creeper—Rare in Oak savanna on Bluff Point (*6091*).

*Vitis aestivalis* Michaux, summer grape—Not seen during this survey (*Falls & Klawe 646* in 1951, TRT).

*V. riparia* Michaux, river-bank grape—Occasional but widespread in Oak savanna and Cottonwood-Red Cedar savanna and on dry dunes (*5675*).

TILIACEAE

*Tilia americana* L., basswood—Occasional and scattered in Red Oak-Sugar Maple forest and Oak savanna (*6108*).

MALVACEAE

**Abutilon theophrasti* Medikus, velvet-leaf—Rare; a weed in one garden near the base of the Point (*6398*).

*Hibiscus moscheutos* L. (incl. *H. palustris*), swamp rose mallow—Rare and scattered in wet meadows and emergent wetlands; the rarity of *Hibiscus* on the Point is surprising considering its abundance in similar habitats elsewhere on Lake Erie (*6132*). (Ford 1989).

HYPERICACEAE

*Hypericum kalmianum* L., Kalm's St. John's-wort—Abundant and widespread in wet meadows (*5302*).

*H. majus* (A. Gray) Britton, St. John's-wort—Occasional and scattered in wet meadows and emergent wetlands (*6161*).

**H. perforatum* L., common St. John's-wort—Occasional but widespread in weedy habitats, Oak savanna, and Cottonwood-Red Cedar savanna (*5957*).

*H. punctatum* Lam., spotted St. John's-wort—Rare and local in moist Bur Oak-Basswood-Hackberry savanna on Ryerson's Island (*6068*).

*Triadenum fraseri* (Spach) Gleason (*Hypericum virginicum* var. *fraseri*), marsh St. John's-wort—Occasional and scattered in emergent wetlands and wet meadows (*5292*).

VIOLACEAE

*Viola affinis* Le Conte, Le Conte's violet—Rare and local in moist depressions in Oak savanna (*5499*).

**V. arvensis* Murray, field pansy—Rare and local in weedy sites and Oak savanna (*5511*).

*V. blanda* Willd. (incl. *V. incognita*), sweet white violet—Occasional and scattered in White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*5455*).

*V. conspersa* Reichenb., dog violet—Occasional but widespread in Red Oak-Sugar Maple forest and Oak savanna (*5461*).

*V. cucullata* Aiton, marsh violet—Rare and scattered in wet meadows and Tamarack-White Cedar swamp (*5459*).

*V. macloskeyi* F. Lloyd (incl. *V. pallens*), smooth white violet—Rare and local in Tamarack-White Cedar swamp and wet sedge meadows (*5341, 5456*).

*V. pubescens* Aiton, yellow violet—Not seen during this survey (*Sutherland 7530*, MICH).

*V. rostrata* Pursh, long-spurred violet—Occasional at one site in a small Red Oak-Sugar Maple forest remnant near the south beach (*5468c*).

*V. sororia* Willd. (incl. *V. papilionacea*), common blue violet—Rare and local in wet meadows on Ryerson's Island (*5513*).

LYTHRACEAE

*Decodon verticillatus* (L.) Elliott, swamp loosestrife—Abundant and widespread in emergent wetlands, frequently a major dominant over large areas; No. *8378* is a white-flowered form (*5998, 8378*).

**Lythrum salicaria* L., purple loosestrife—Occasional and local in emergent wetlands near the base of the Point (*6163*).

ONAGRACEAE

*Circaea lutetiana* L. (*C. quadrisulcata*), enchanter's-nightshade—Occasional and local in thickets on Ryerson's Island (*6058*). (Boufford 1983).

*Epilobium coloratum* Biehler, purple-leaved willow-herb—Rare and local in emergent wetlands (*5276*).

**E. hirsutum* L., great hairy willow-herb—Rare in emergent wetlands near the base of the Point (*5954*).

*E. leptophyllum* Raf., narrow-leaved willow-herb—Rare in wet meadows on Bluff Point (*6078*).

*E. strictum* Sprengel, downy willow-herb—Rare and local in floating sedge mats near Little Creek (*6094*).

*Oenothera biennis* L., common evening-primrose—Occasional and scattered on dry dunes and in Oak savanna, Cottonwood-Red Cedar savanna, and weedy habitats (*6031*).

*O. parviflora* L., small-flowered evening-primrose—Occasional and scattered on dry dunes (*6023*).

HALORAGIDACEAE

*Myriophyllum heterophyllum* Michaux, water-milfoil—Occasional but widespread in various submerged and floating-leaved aquatic communities; locally a major dominant (*5962*). Figure 26.

*M. sibiricum* Komarov (*M. exalbescens*)—Rare; a few plants in Bluff Pond, near Bluff Point (*6073*). (Ceska & Ceska 1986, Aiken & Cronquist 1988).

**M. spicatum* L., eurasian water-milfoil—Occasional but widespread in various submerged and floating-leaved aquatic communities; locally a dominant, especially near the base of the Point (*5323*).

*M. verticillatum* L.—Abundant and widespread in various submerged and floating-leaved aquatic communities; often a major dominant, especially in inland pools (*5239, 5277*).

*Proserpinaca palustris* L., mermaid weed—Occasional and scattered in wet meadows and emergent wetlands (*5993*).

ARALIACEAE

*Aralia hispida* Vent., bristly sarsaparilla—Not seen during this survey (*Falls & Klawe 724* in 1951, TRT).

APIACEAE

*Angelica atropurpurea* L., angelica—Rare and local in wet grass meadows on Ryerson's Island (*6067*).

*Cicuta bulbifera* L., water-hemlock—Occasional and scattered in wet grass meadows and emergent wetlands (*6061*).

**Daucus carota* L., Queen-Anne's-lace—Occasional and scattered in weedy habitats, Oak savanna, Cottonwood-Red Cedar savanna, and on dry dunes (*6402*).

*Heracleum maximum* Bartram (*H. lanatum*), cow parsnip—Occasional at one site in a wet meadow near the base of the Point (*5564*).

CORNACEAE

*Cornus amomum* Miller subsp. *obliqua* (Raf.) J.S. Wilson, pale dogwood—Occasional but widespread in wet grass meadows and emergent wetlands (*5672*). (Wilson 1965).

*C. canadensis* L., bunchberry—Not seen during this survey (*Falls & Klawe 449* in 1951, TRT).

*C. drummondii* C.A. Meyer, rough-leaved dogwood—Occasional and scattered in wet meadows near the base of the Point and on Ryerson's Island (*5404, 6049*).

*C. foemina* Miller subsp. *racemosa* (Lam.) J.S. Wilson, gray dogwood—Occasional and local on low dunes and in wet sedge meadows near the base of the Point (*5677*). (Wilson 1965).

*C. rugosa* Lam., round-leaved dogwood—Not seen during this survey (*Falls & Klawe 726*, TRT).

*C. stolonifera* Michaux, red-osier—Occasional and scattered in wet meadows and on low dunes, mostly near the base of the Point (*5681*).

ERICACEAE

*Arctostaphylos uva-ursi* (L.) Sprengel, common bearberry—Abundant but local on dunes and in Cottonwood-Red Cedar savanna and sunny openings in White Pine-White Cedar-Red Cedar forest, often heavily deer browsed (*Landon* in 1949, OAC).

*Pterospora andromedea* Nutt., giant bird's nest—Not seen during this survey (*Scott* in 1898, TRT).

*Pyrola chlorantha* Sw. (*P. virens*), greenish-flowered pyrola—Not seen during this survey (*Falls & Klawe 447* in 1951, TRT). (Haber 1972).

PRIMULACEAE

*Lysimachia terrestris* (L.) BSP., swamp candles—Occasional and scattered in wet meadows and Tamarack-White Cedar swamp (*6007*).

*L. thyrsiflora* L., tufted loosestrife—Occasional and scattered in wet meadows and Tamarack-White Cedar swamp (*5599*).

*Trientalis borealis* Raf., starflower—Occasional but widespread in White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*5457*).

OLEACEAE

*Fraxinus americana* L., white ash—Occasional but widespread in Red Oak-Sugar Maple forest and Oak savanna (*5487*).

*F. pennsylvanica* Marshall, red ash—Occasional and scattered in Oak savanna (*5614*).

GENTIANACEAE

*Gentiana andrewsii* Griseb., closed gentian—Occasional and local in wet sedge meadows near the base of the Point (*6408*).

*Gentianopsis crinita* (Froelich) Ma (*Gentiana crinita*), fringed gentian—Abundant and widespread in wet sedge meadows (*Ramsay* in 1972, TRT). (Iltis 1965).

*Menyanthes trifoliata* L., buckbean—Rare and local in floating sedge mats near Gravelly Bay (*5627*).

APOCYNACEAE

*Apocynum androsaemifolium* L., spreading dogbane—Not seen during this survey (*Landon 571* in 1948, HAM).

*A. cannabinum* L., indian hemp—Occasional and scattered in wet sedge meadows (*6090*).

*A. sibiricum* Jacq., dogbane—Not seen during this survey (*Falls & Klawe 473, 583* in 1951, TRT).

ASCLEPIADACEAE

*Asclepias incarnata* L., swamp milkweed—Occasional but widespread in wet meadows and emergent wetlands (*5983*).

*A. syriaca* L., common milkweed—Abundant and widespread on dry dunes and in Oak savanna, Cottonwood-Red Cedar savanna, and openings in Red Oak-Sugar Maple forest and White Pine-White Cedar-Red Cedar forest (*Johnson* in 1972, TRT).

*A. tuberosa* L., butterfly-weed—Not seen during this survey (*Kroetsch* in 1980, DAO).

CONVOLVULACEAE

*Calystegia sepium* (L.) R. Br. (*Convolulus sepium*), hedge bindweed—Occasional but widespread in wet meadows and emergent wetlands (*6041*). (Brummitt 1980).

*C. spithamea* (L.) R. Br. (*Convolvulus spithameus*), low bindweed—Rare at one site in an opening in a White Pine-White Cedar-Red Cedar forest (*5641*).

*Cuscuta gronovii* Willd., dodder—Occasional and scattered in wet meadows and emergent wetlands (*5234*).

BORAGINACEAE

**Buglossoides arvensis* (L.) I.M. Johnston (*Lithospermum arvense*), corn gromwell—Occasional in Oak savanna at the east end of Courtright Ridge (*5512*).

**Cynoglossum officinale* L., common hound's-tongue—Occasional and scattered in Red Oak-Sugar Maple forest, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*5597*).

*Hackelia virginiana* (L.) I.M. Johnston, stickseed—Rare and scattered in White Pine-White Cedar-Red Cedar forest (*5975*).

*Lithospermum caroliniense* (Walter) MacMillan subsp. *croceum* (Fern.) Cusick, puccoon—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna and Oak savanna (*5634*). (Cusick 1985).

*Myosotis laxa* Lehm., forget-me-not—Not seen during this survey (*Dean* in 1981, DAO).

*Onosmodium molle* Michaux, false gromwell—Rare in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*6010*).

VERBENACEAE

*Verbena hastata* L., blue vervain—Occasional and scattered in wet meadows and emergent wetlands, No. 8375 is the striking forma *rosea* Cheney (*5991, 8375*).

*V. urticifolia* L., white vervain—Occasional and scattered in wet meadows, emergent wetlands, and openings in White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*6017*).

LAMIACEAE

**Glechoma hederacea* L., gill-over-the-ground—Occasional and scattered in weedy habitats (*5529*).

**Leonurus cardiaca* L., motherwort—Occasional but widespread in weedy habitats, Oak savanna, White Pine-White Cedar-Red Cedar forest, and Red Oak-Sugar Maple forest (*6112*).

*Lycopus americanus* Muhlenb.—Occasional but widespread in wet meadows and emergent wetlands (*6016*).

**L. europaeus* L.—Rare and scattered in wet meadows and emergent wetlands and on beach strands (*5308*).

*L. uniflorus* Michaux—Occasional but widespread in wet meadows and emergent wetlands and on beach strands (*5237, 5294*).

*Mentha arvensis* L., mint—Occasional but widespread in wet meadows, emergent wetlands, and Tamarack-White Cedar swamp (*6059*).

**M. piperita* L., peppermint—Not seen during this survey (*Senn & Soper 506* in 1938, TRT).

*Monarda fistulosa* L., wild bergamot—Occasional and local on dry dunes near the base of the Point and on Ryerson's Island (*6070*).

**Nepeta cataria* L., catnip—Occasional but widespread in weedy habitats, Oak savanna, White Pine-White Cedar-Red Cedar forest, and Red Oak-Sugar Maple forest (*6003*).

*Physostegia virginiana* (L.) Benth., false dragonhead—Rare in one wet sedge meadow near the base of the Point (*5395*).

*Prunella vulgaris* L., heal-all—Occasional but widespread in wet meadows, Oak savanna, Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, and weedy habitats (*6406*).

*Pycnanthemum verticillatum* (Michaux) Pers., mountain-mint—Not seen during this survey (*Robb* in 1936, TRT).

*Satureja glabella* (Michaux) Briq. (*S. arkansana*), calamint—Not seen during this survey (*Landon, Gaiser, & Snure* in 1936, HAM, TRT).

**S. vulgaris* (L.) Fritsch, basil—Occasional in Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, and Oak savanna (*5956*).

*Scutellaria galericulata* L. (incl. *S. epilobifolia*), common skullcap—Occasional but widespread on beach strands and in wet meadows, emergent wetlands, and Tamarack-White Cedar swamp (*5985*).

*S. lateriflora* L., mad-dog skullcap—Occasional and scattered in wet meadows and emergent wetlands and on beach strands (*6411*).

*S. parvula* Michaux, skullcap—Not seen during this survey (*Dean 48*, DAO).

*Stachys tenuifolia* Willd. (incl. *S. hispida*) woundwort—Occasional and scattered in wet grass meadows (*5393*).

*S. palustris* L., woundwort—Not seen during this survey (*Falls & Klawe 492* in 1951, TRT).

*Teucrium canadense* L. (incl. *T. occidentale*), American germander—Abundant and widespread in wet meadows, emergent wetlands, low dunes, and Oak savanna (*5318*).

SOLANACEAE

**Datura stramonium* L., jimsonweed—Rare and local in weedy habitats (*6133*).

*Physalis heterophylla* Nees, ground-cherry—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*5252*).

**Solanum dulcamara* L., nightshade—Occasional but widespread in wet meadows, emergent wetlands, White Pine-White Cedar-Red Cedar forest, Red Oak-Sugar Maple forest, and Oak savanna (*5588*).

*S. ptycanthum* DC., black nightshade—Occasional and scattered in weedy habitats and on beach strands (*6030*). (Schilling 1981).

SCROPHULARIACEAE

*Agalinis paupercula* (A. Gray) Britton (*Gerardia paupercula*), gerardia—Abundant and widespread in wet sedge meadows (*Johnson* in 1972, TRT).

*Castilleja coccinea* (L.) Sprengel, scarlet painted-cup—Abundant and widespread in wet sedge meadows (*5448*).

**Chaenorrhinum* minus (L.) Lange, dwarf snapdragon—Rare and scattered in weedy habitats, especially gravelly roadsides (*6422*).

**Linaria vulgaris* Miller, butter-and-eggs—Occasional and scattered in weedy habitats and Oak savanna (unknown collector in 1979, DAO).

*Melampyrum lineare* Desr., cow-wheat—Occasional and scattered in White Pine-White Cedar-Red Cedar forest (*6001*).

*Mimulus ringens* L., monkey-flower—Occasional and scattered in wet meadows and emergent wetlands (*6042*).

**Verbascum thapsus* L., common mullein—Abundant and widespread in weedy habitats, Oak savanna, Cottonwood-Red Cedar savanna, and White Pine-White Cedar-Red Cedar forest and on dry dunes (*5955*).

**Veronica arvensis* L., corn speedwell—Occasional and scattered in Oak savanna and weedy habitats (*5441*).

*V. officinalis* L., common speedwell—Not seen during this survey (*Dean 54*, DAO).

*V. peregrina* L., purslane speedwell—Rare and local in weedy habitats (*5547*).

OROBANCHACEAE

*Conopholis americana* (L.) Wallr., squawroot—Rare and local in Red Oak-Sugar Maple forest (*5666, 6109*).

*Orobanche uniflora* L., one-flowered cancer-root—Not seen during this survey (*House* in 1986, MICH).

LENTIBULARIACEAE

*Utricularia cornuta* Michaux, horned bladderwort—Abundant but very local in wet sedge meadows between Gravelly Bay and the tip of the Point (*6014*).

*U. gibba* L., humped bladderwort—Rare and scattered in pools in wet sedge meadows and emergent wetlands, flowering only when stranded (*5340, 5997*).

*U. intermedia* Hayne, flat-leaved bladderwort—Occasional but widespread in wet sedge meadows and emergent wetlands (*5360, 5623*).

*U. minor* L., small-flowered bladderwort—Occasional and scattered in pools in wet sedge meadows and emergent wetlands (*5359, 5622*).

*U. resupinata* Bigelow, bladderwort—Abundant but local in shallow water and on shorelines of sandy-bottomed ponds in the vicinity of Gravelly Bay (*5963, 8381*).

*U. vulgaris* L., common bladderwort—Abundant and widespread in emergent wetlands and various submerged and floating-leaved aquatic communities (*5362*).

ACANTHACEAE

*Justicia americana* (L.) Vahl (*Dianthera americana*), water-willow—Not seen during this survey (*Heffernan* in 1977, DAO).

PHRYMACEAE

*Phryma leptostachya* L., lopseed—Rare in shrubby Cottonwood savanna on Ryerson's Island (*Sutherland 7528*, MICH).

PLANTAGINACEAE

**Plantago lanceolata* L., English plantain—Occasional but widespread in weedy habitats and Oak savanna (*Johnson* in 1972, TRT).

**P. major* L., common plantain—Occasional but widespread in weedy habitats, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*6403*).

*P. rugelii* Decne., plantain—Occasional and scattered in weedy habitats and wet meadows (*6404*).

RUBIACEAE

*Cephalanthus occidentalis* L., buttonbush—Abundant and widespread in wet meadows, emergent wetlands, and wet depressions in Red Oak-Sugar Maple forest; this species grows in deeper water than any other woody plant on the Point (*5979*).

*Galium aparine* L., cleavers—Occasional and scattered in Oak savanna, White Pine-White Cedar-Red Cedar forest, and Red Oak-Sugar Maple forest (*5440*).

*G. asprellum* Michaux, rough bedstraw—Occasional and scattered in wet meadows and Tamarack-White Cedar swamp (*6053*).

*G. circaezans* Michaux, wild licorice—Rare and local in Red Oak-Sugar Maple forest (*6118*).

*G. pilosum* Aiton—Rare in White Pine-White Cedar-Red Cedar forest near Gravelly Bay (*5638*).

*G. tinctorium* L.—Occasional and scattered in wet meadows, emergent wetlands, and Tamarack-White Cedar swamp (*5296*).

*G. trifidum* L.—Rare in floating sedge mats near Gravelly Bay (*5295, 6099*).

*G. triflorum* Michaux, sweet-scented bedstraw—Occasional but widespread in Red Oak-Sugar Maple forest, White Pine-White Cedar-Red Cedar forest, and Tamarack-White Cedar swamp (*5576*).

*Mitchella repens* L., partridge-berry—Not seen during this survey (*Falls & Klawe 439* in 1951, TRT).

CAPRIFOLIACEAE

*Linnaea borealis* L., twinflower—Occasional and local in White Pine-White Cedar-Red Cedar forest and Tamarack-White Cedar swamp (*5574*).

*Lonicera dioica* L., honeysuckle—Rare and local in White Pine-White Cedar-Red Cedar forest (*5995*).

**L. xylosteum* L., fly-honeysuckle—Rare and local in weedy habitats near the base of the Point. Our collection has the technical characters of *L. xylosteum*, but with somewhat narrower leaves than many specimens; it may be a hybrid (*5688*).

*Sambucus canadensis* L., common elder—Rare but widespread in Oak savanna, wet meadows, and Tamarack-White Cedar swamp; sometimes tree-like on the Point, a plant on a ridge 0.8 km east of Gravelly Bay had a trunk 13 cm in diameter at breast height (*5440a, 6127*).

*S. pubens* Michaux, red-berried elder—Rare in Cottonwood savanna near the base of the Point (*5691*).

*Symphoricarpos albus* (L.) S.F. Blake, snowberry—Occasional and scattered in White Pine-White Cedar-Red Cedar forest and Oak savanna (*6083*).

*Viburnum lentago* L., nannyberry—Rare and scattered in Tamarack-White Cedar swamp (*5573*).

CUCURBITACEAE

*Echinocystis lobata* (Michaux) Torrey & A. Gray, wild cucumber—Rare and local in weedy habitats and wet meadows (*6413*).

CAMPANULACEAE

*Campanula aparinoides* Pursh, marsh bellflower—Occasional and scattered in wet meadows and emergent wetlands (*5299, 6100*).

*C. uliginosa* Rydb., marsh bellflower—Rare and local in floating sedge mats (*6101*).

*Triodanis perfoliata* (L.) Nieuwl. (*Specularia perfoliata*), venus's looking-glass—Rare and local in openings in Red Oak-Sugar Maple forest (*6117*).

LOBELIACEAE

*Lobelia kalmii* L., brook lobelia—Abundant and widespread in wet sedge meadows (*6018*).

*L. siphilitica* L., great lobelia—Rare and scattered in wet meadows (*6407*).

*L. spicata* L., spiked lobelia—Not seen during this survey (*Ball 40571*, TRTE).

ASTERACEAE

*Achillea millefolium* L., common yarrow—Occasional but widespread in all but the wettest habitats on the Point (*6027*).

**Ambrosia artemisiifolia* L., common ragweed—Occasional but widespread in weedy habitats, Oak savanna, and on dry dunes (*Johnson* in 1972, TRT).

*A. trifida* L., great ragweed—Rare in weedy habitats at the base of the Point (*6417*).

*Anaphalis margaritacea* (L.) Benth. & Hook., pearly everlasting—Occasional and scattered in Oak savanna and White Pine-White Cedar-Red Cedar forest (*5251*).

*Antennaria neodioica* E. Greene subsp. *neodioica,* pussy's toes—Occasional and scattered in Red Oak-Sugar Maple forest, Oak savanna, White Pine-White Cedar-Red Cedar forest, and on dry dunes (*5493*). (Bayer & Stebbins 1982). Det. G.L. Stebbins.

*A. parlinii* Fern. subsp. *fallax* (E. Greene) R. Bayer & Stebbins, pussy's toes—Occasional and scattered in Red Oak-Sugar Maple forest, Oak savanna, White Pine-White Cedar-Red Cedar forest, and on dry dunes (*5450, 5494*). (Bayer & Stebbins 1982). Det. G.L. Stebbins.

**Anthemis cotula* L., mayweed—Rare and local in weedy habitats (*5243a*).

**Arctium minus* Schk., common burdock—Occasional and scattered in weedy habitats (*6416*).

**Artemisia biennis* Willd., biennial wormwood—Occasional and local in weedy habitats (*8370*).

*A. campestris* L. (incl. *A. caudata*), tall wormwood—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna (*6146*).

**A. vulgaris* L., common mugwort—Rare and local in weedy habitats (*8368*).

*Aster borealis* (Torrey & A. Gray) Prov. (*A. junciformis*), rush aster— Rare and local in floating sedge mats near Gravelly Bay (*5353, 6097*). (Semple & Brouillet 1980).

*A. dumosus* L., bushy aster—Abundant and widespread in wet meadows and Oak savanna (*5297*).

*A. lanceolatus* Willd. (*A. simplex*), panicled aster—Occasional but widespread in wet meadows and emergent wetlands (*Senn & Soper 436A, 438, 607*, DAO, TRT). (Semple 1979).

*A. oolentangiensis* Riddell (*A. azureus*), azure aster—Occasional and scattered in Oak savanna (*5254*). (Jones 1983).

*A. pilosus* Willd., frost aster—Occasional but widespread on dry dunes and in Cottonwood-Red Cedar savanna and wet meadows (*5389*).

*Bidens beckii* Torrey, water marigold—Occasional but widespread in various submerged and floating-leaved aquatic communities (*5290, 6128*).

*B. cernuus* L., stick-tight—Abundant and widespread on beach strands and in wet meadows and emergent wetlands (*Johnson* in 1972, TRT).

*B. connatus* Muhlenb., beggar-ticks—Abundant and widespread in wet meadows, emergent wetlands, and on beach strands (*5235, 5331*).

*B. coronatus* (L.) Britton, tickseed-sunflower—Abundant and widespread in wet meadows and emergent wetlands (*5243*).

*B. discoideus* (Torrey & A. Gray) Britton, bur-marigold—Occasional and local in emergent wetlands near the Little Creek Ridges (*5366*).

*B. frondosus* L., beggar-ticks—Abundant and widespread on beach strands and in wet meadows, Red Oak-Sugar Maple forest, Tamarack-White Cedar swamp, and emergent wetlands (*5236*).

**Centaurea maculosa* Lam., knapweed—Rare and scattered in Oak savanna and Cottonwood-Red Cedar savanna (*Heffernan* in 1976, DAO).

**Cichorium intybus* L., chicory—Occasional and scattered in weedy habitats (*6423*).

**Cirsium arvense* (L.) Scop., Canada thistle—Occasional and scattered in weedy habitats and Oak savanna (*5996*).

*C. muticum* Michaux, swamp thistle—Rare and scattered in wet meadows and Tamarack-White Cedar swamp (*6052*).

**C. vulgare* (Savi) Tenore, bull-thistle—Occasional and scattered in weedy habitats, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*Falls & Klawe 568*, TRT).

*Conyza canadensis* (L.) Cronq., horse-weed—Occasional and scattered in weedy habitats, on beach strands, in Oak savanna, and in White Pine-White Cedar-Red Cedar forest; No. *8377* is from a population with densely branched inflorescences wider than long (*5961, 8377*).

**Crepis tectorum* L., hawk's beard—Rare in weedy habitats near the base of the Point (*5684*).

*Erechtites hieracifolia* (L.) Raf., pilewort—Occasional and scattered on beach strands and in weedy habitats, wet meadows, and emergent wetlands (*5240*).

*Erigeron annuus* (L.) Pers., daisy-fleabane—Rare and local in weedy habitats, Oak savanna, and openings in Red Oak-Sugar Maple forest (*8374*).

*E. philadelphicus* L., fleabane—Occasional and scattered on beach strands and in weedy habitats, wet meadows, and Tamarack-White Cedar swamp (*5539*).

*E. pulchellus* Michaux, robin's-plantain—Not seen during this survey (*Falls & Klawe 363* in 1951, TRT).

*E. strigosus* Muhlenb., white-top—Occasional and scattered on dry dunes and in Oak savanna, White Pine-White Cedar-Red Cedar forest, and Red Oak-Sugar Maple forest (*6110*).

*Eupatorium maculatum* L., joe-pye-weed—Occasional and scattered in wet meadows and emergent wetlands (*6125*).

*E. perfoliatum* L., boneset—Occasional and scattered in wet meadows and emergent wetlands (*6088*).

*E. rugosum* Houtt., white snakeroot—Occasional and scattered in Red Oak-Sugar Maple forest and Tamarack-White Cedar swamp (*6069*).

*Euthamia graminifolia* (L.) Nutt. (*Solidago graminifolia*), lance-leaved goldenrod—Abundant and widespread in wet meadows (*6152*). (Sieren 1981).

*Gnaphalium obtusifolium* L., catfoot—Occasional and scattered in Oak savanna and White Pine-White Cedar-Red Cedar forest (*6093*).

*G. uliginosum* L., low cudweed—Rare and scattered in weedy habitats and on beach strands (*5407*).

*Helenium autumnale* L., sneezeweed—Abundant and widespread in wet meadows and emergent wetlands (*Scoggan 14859*, CAN).

**Helianthus annuus* L., common sunflower—Rare but widespread on beach strands (*6033*).

*H. strumosus* L., sunflower—Rare but scattered in Oak savanna and wet meadows (*Falls & Klawe 753*, TRT).

**Hieracium aurantiacum* L., orange hawkweed—Occasional and scattered in weedy habitats, Oak savanna, and White Pine-White Cedar-Red Cedar forest (*5643*).

*H. *caespitosum* Dumort. (*H. pratense*), king devil—Occasional and scattered in weedy habitats and Oak savanna and on dry dunes (*5595, 5606*).

*H. gronovii* L., hawkweed—Rare at one site in Oak savanna on Squires Ridge (*5378*).

*H. *piloselloides* Villars (*H. florentinum*), king devil—Occasional and local in weedy habitats near the base of the Point (*5676*).

**Hypochoeris radicata* L., cat's-ear—Not seen during this survey (*Sutherland 8053*, MICH).

*Lactuca canadensis* L., wild lettuce—Occasional and scattered in Oak savanna and Red Oak-Sugar Maple forest (*5263, 6102*).

*L. *serriola* L., prickly lettuce—Occasional and scattered in weedy habitats (*6414*).

**Leucanthemum vulgare* Lam. (*Chrysanthemum leucanthemum*), ox-eye daisy— Rare and scattered in weedy habitats, Oak savanna, and Cottonwood-Red Cedar savanna (*Falls & Klawe 421*, TRT).

*Liatris cylindracea* Michaux, cylindric blazing star—Occasional and scattered on dry dunes and in Cottonwood-Red Cedar savanna and the drier edges of wet meadows (*5312*).

**Matricaria matricarioides* (Less.) Porter, pineapple-weed—Occasional and scattered in weedy habitats (*5555*).

*Solidago altissima* L., tall goldenrod—Occasional and scattered in wet meadows (*6156*).

*S. bicolor* L., silver-rod—Occasional but widespread in Oak savanna (*5284*).

*S. caesia* L., blue-stem goldenrod—Rare and local in Red Oak-Sugar Maple forest on Squires Ridge (*8373*).

*S. canadensis* L., Canada goldenrod—Abundant and widespread in wet meadows, Oak savanna, White Pine-White Cedar-Red Cedar forest, Tamarack-White Cedar swamp, Red Oak-Sugar Maple forest, and weedy habitats (*Johnson* in 1972, TRT).

*S. gigantea* Aiton, late goldenrod—Occasional but widespread in wet meadows and Oak savanna (*6141*).

*S. hispida* Muhlenb., hairy goldenrod—Rare and scattered in White Pine-White Cedar-Red Cedar forest (*5286*).

*S. nemoralis* Aiton, gray goldenrod—Abundant and widespread on dry dunes and in Cottonwood-Red Cedar savanna and Oak savanna (*Johnson* in 1972, TRT).

*S. ohioensis* Riddell, Ohio goldenrod—Abundant in wet meadows near the base of the Point, much rarer near the tip (*Falls & Klawe 535*, TRT).

*S. ptarmicoides* (Nees) Boivin (*Aster ptarmicoides*), upland white aster—Occasional and scattered in wet meadows and Cottonwood-Red Cedar savanna and on dry dunes between Gravelly Bay and the tip of the Point (*5328*).

*S. rugosa* Miller, rough-stemmed goldenrod—Rare but scattered in Oak savanna (*5289*).

**Sonchus arvensis* L., field-sow-thistle—Occasional and scattered in weedy habitats, Oak savanna and White Pine-White Cedar-Red Cedar forest (*6039*).

*S. *asper* (L.) Hill, spiny-leaved sow-thistle—Occasional and local in weedy habitats at the base of the Point (*6420*).

**Taraxacum erythrospermum* Besser, red-seeded dandelion—Rare and scattered in Oak savanna and on dry dunes; our collection of this aggregate species was determined as the microspecies *T. scanicum* Dahlst. by R. Doll (*5449*).

*T. *officinale* Weber, common dandelion—Abundant and widespread in all terrestrial habitats on the Point (*5453*).

**Tragopogon dubius* Scop., goat's beard—Occasional but widespread on dry dunes and in Oak savanna, Cottonwood-Red Cedar savanna, and White Pine-White Cedar-Red Cedar forest (*5604*).

*T. *porrifolius* L., salsify—Rare in weedy habitats near the base of the Point (*5554*).

**Tussilago farfara* L., coltsfoot—Rare and local on beach strands and low dunes (*5504*).

*Virgulus ericoides* (L.) Reveal & Keener (*Aster ericoides*), heath aster—Occasional and scattered in Oak savanna and Cottonwood-Red Cedar savanna (*Johnson* in 1972, TRT). (Reveal & Keener 1981).

*V. novae-angliae* (L.) Reveal & Keener (*Aster novae-angliae*), New England aster—Rare

and scattered in wet meadows and weedy habitats (*Klinkenberg* in 1980, MICH). (Reveal & Keener 1981).

*Xanthium strumarium* L. (incl. *X. chinense* and *X. italicum*), cocklebur—Abundant and widespread on beach strands and in weedy habitats (*5253*).

## *9. Index to Genera in the Annotated List*

Genera included only as synonyms are in italics.

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On the cover: *Sand dune blowout burying trees in Oak Savanna along the south beach near the Little Creek Ridges, Long Point, Ontario.*
*Photographed by A.A. Reznicek, 27 August 1988.*

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# THE MICHIGAN BOTANIST

October, 1989



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# THE VEGETATION OF INDIAN BOWL WET PRAIRIE AND ITS ADJACENT PLANT COMMUNITIES

## I. DESCRIPTION OF THE VEGETATION

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Indian Bowl Prairie and its adjacent plant communities lie between the St. Joseph River and the Valparaiso moraine in central Berrien County, Michigan. This area was called to the author's attention in the spring of 1980 by Ms. Margaret Kohring, at that time of the Michigan Field Office of the Nature Conservancy, as a high priority site for Conservancy acquisition and in need of study. Although many species had been reported from this tract, few collections had been made of the vascular plants and there were no quantitative ecological studies of the area.

Two aspects of this tract make it unique in Michigan. The first is the large bowl-shaped depression in the west side of the moraine, which gives the area its name, and the second is the presence of a large wet prairie. No landforms similar to the bowl formation have been located in the state and wet prairies are infrequent and of small size in Michigan. Besides these major aspects, others add to the floristic and ecological importance of the tract. Several state threatened and special concern plants have been reported from the area (Medley 1972; Schaddalee 1980; Thompson et al. 1976). There is little evidence of disturbance, i.e., very few introduced or naturalized species are present. The St. Joseph River, Love Creek, and the Valparaiso moraine are natural boundaries which have isolated this tract from outside disturbance. These natural barriers, as well as the saturated nature of the soil in the prairie and bowl floor, have resulted in the presence of a unique natural area in the midst of a heavily agricultural portion of Michigan.

## PREVIOUS REPORTS ON THE AREA

Medley (1972) and Thompson (1975) have compiled extensive species lists for the prairie, tamarack swamp, and bowl. Medley (1972) suggested that this may be the largest wet prairie remaining in Michigan. His report lists ten species of plants which were later designated as threatened or

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special concern in Michigan (Beaman et. al. 1985). Thompson (1975) published a list of approximately 200 species of angiosperms for the Indian Bowl prairie in his comparison of wet, mesic, and dry prairie stands in southern Michigan. The Michigan Natural Areas Council issued a brief report (Thompson et al. 1976) listing a few of the species found in each major community type, and indicated that almost 500 species of plants had been identified in the Indian Bowl area. The report recommended that the land be acquired by the Michigan Department of Natural Resources or a similar organization. It was suggested that the prairie be designated a Managed Tract and the remaining area a Natural Area Preserve. Barnes and Kohring (1978) prepared a site plan and environmental impact assessment of the Indian Bowl area for the Berrien County Parks and Recreation Commission and proposed the acquisition of the area by the county. In the Barnes and Kohring report, some development was proposed including a boardwalk through the prairie and swamp forest, trails through the bowl, and cross-country ski trails through the entire area. The most recent report, prior to the present study, was prepared for the Michigan Field Office of the Nature Conservancy by Schaddalee (1980). It includes a list of 16 reported state threatened and special concern (rare) species of vascular plants and three species of threatened and rare animals. Brief descriptions of the major community types are included, as well as approximate locations of most of the reported threatened and special concern (rare) species. A detailed list of ownership is included. The end of the report consists of a list of species reported for the area compiled mostly from Medley's (1972) list.

## PHYSICAL SETTING

The study area was chosen to include the least disturbed and the floristically richest portion within the possible 325 acres suggested for inclusion in a preserve by Barnes and Kohring (1978). This included an area of approximately 260 acres located at the W 1/2 of section 8 and the NW 1/4 of the NW 1/4 of section 17, T6S, R17W, Berrien Township, Berrien County, Michigan (Fig. 1). The town of Berrien Springs is one mile southwest of the Indian Bowl tract. The natural boundaries are the St. Joseph River to the west, Love Creek to the south, and the Valparaiso moraine to the east. The elevation of the area varies from 600 to 750 feet above sea level. A network of streams runs throughout the tract. These streams are fed by surface runoff from the slopes of the moraine and a series of seepage springs located in various places along the base of the moraine.

Two major landforms dominate the study area: the bowl-formation in the Valparaiso moraine (Fig. 2) and the floodplain of the St. Joseph River. The bowl-formation has steeply sloping sides of 25 to 75 percent slope, and a relatively level central area of 0 to 15 percent slope (hereafter referred to as the slopes and the bowl floor, respectively). Between the bowl-formation and the St. Joseph River lies the floodplain which is level to gently sloping at an elevation of 600 feet above sea level.

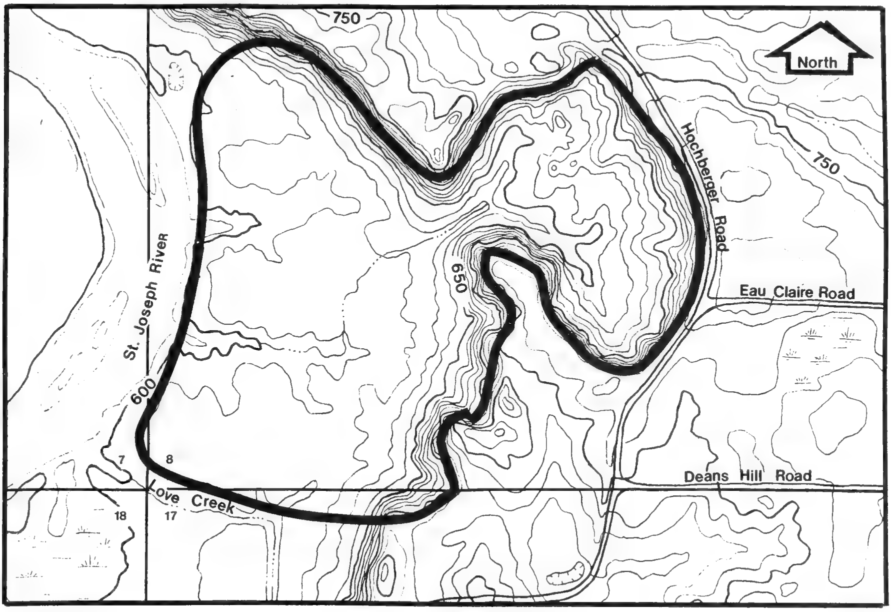


Figure 1. Topographic map of the Indian Bowl study area, Berrien County, Michigan.

Figure 2. View (facing west) of the Indian Bowl from the wet prairie (foreground), May 1981.

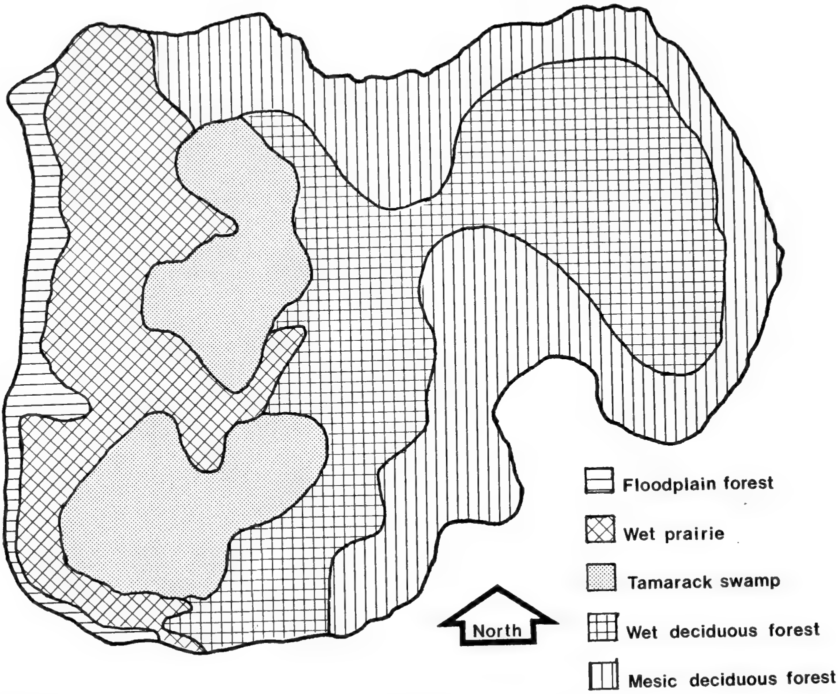


Figure 3. Major plant communities within the Indian Bowl study area.

Four major community types may be observed by inspection in the Indian Bowl tract (Fig. 3). The western portion of the floodplain is wet prairie, with a very narrow strip of floodplain forest along the St. Joseph River. East of the prairie lies a discontinuous stretch of tamarack swamp running in a north-south direction. East of the tamarack swamp lies the bowl-formation. Mesic deciduous forest occurs on the bowl. The forest extends through a gap in the west side of the bowl and forms a thicket between the tamarack swamp and the base of the moraine.

The wet prairie in the Indian Bowl site is approximately 90 acres in size and is, as Medley (1972) suggested, perhaps the largest in Michigan. In the past, a few cattle have been allowed to graze the prairie but this has not occurred since the mid-1940's (Mrs. C. Lyngby, pers. comm.; see Kron (1982) for historical background of the Indian Bowl area). Several state threatened and special concern (rare) plants can be found in the wet prairie. These include: *Silphium integrifolium, Filipendula rubra* (Fig. 4), and *Polemonium reptans. Silphium* and *Filipendula* are widespread throughout the prairie.

State threatened and special concern (rare) plants have been reported

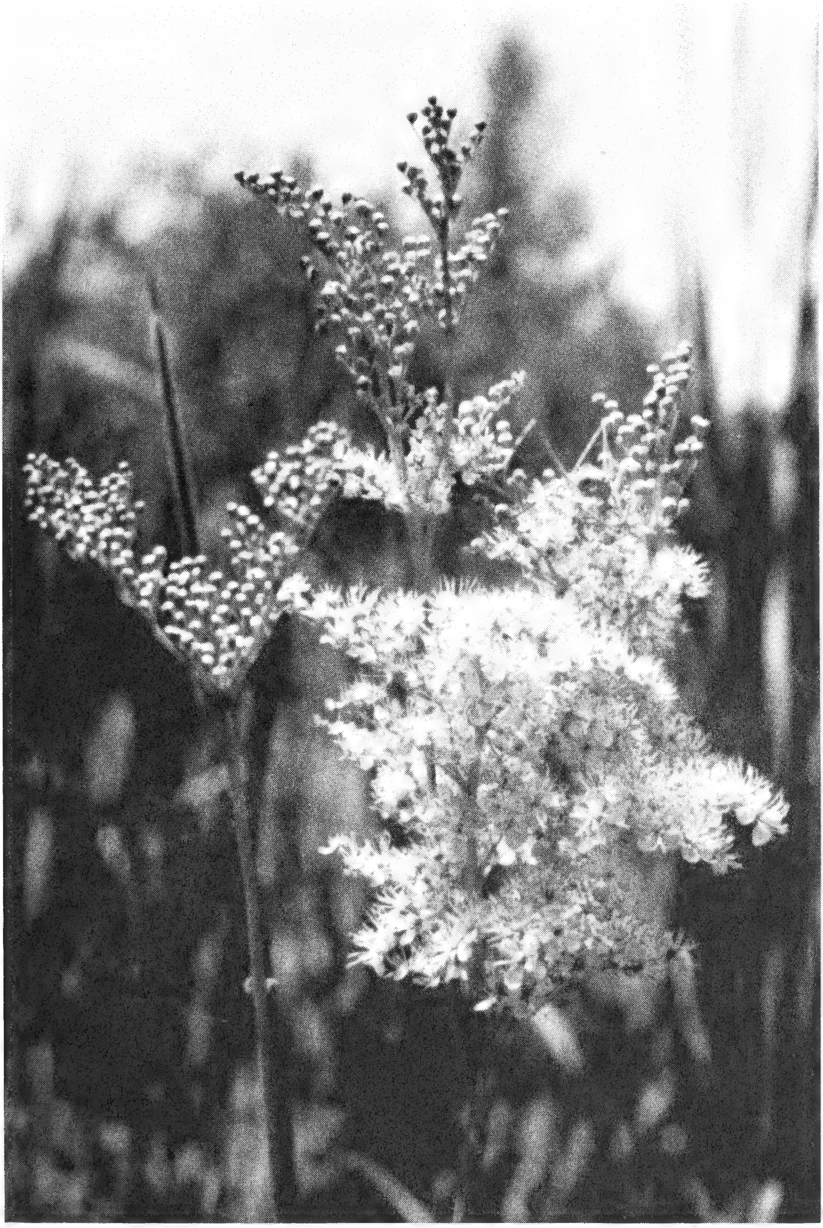

Figure 4. *Filipendula rubra,* Queen-of-the-Prairie, July 1980.

from the bowl as well as the wet prairie. These include *Trillium recurvatum* and *Polemonium reptans* found on the bowl floor.

## SOILS

### METHODS

Soil samples were taken from the primary soil types within the wet prairie, tamarack swamp, and slopes of the bowl. Fifteen cores were sampled from the wet prairie and fifteen from the tamarack swamp using a one-inch bore, one meter in length. Since the nature of the soils on the slopes of the bowl did not lend themselves to sampling by the bore, ten samples of the A horizon were taken from each aspect of the slopes of the bowl. Each set of samples from a given area was mixed and a sample of that mixture was sent to the Michigan State University Soil Testing Service for analysis. The samples were analyzed for potassium, phosphorus, calcium, magnesium, zinc, iron, manganese, and copper.

### RESULTS

Results of the analysis are shown in Table 1. According to the soil survey of Berrien County (Larson 1980) soils in the study area range from well-drained, sandy loam on the slopes of the bowl to frequently flooded, poorly-drained muck in the bowl floor and wet prairie (Fig. 5).

The wet prairie, tamarack swamp, and much of the wet forest of the bowl floor occur on Houghton and Houghton-Kerston mucks. These organic soils are frequently flooded and are found in sloping to level sites. The pH of these soils in the Indian Bowl site is slightly acid to nearly neutral (Table 1). Calcium and magnesium content are quite high in these soils in the Indian Bowl site. The tamarack swamp and wet forest soils contain a greater amount of calcium than the wet prairie. Calciphilic species such as *Filipendula rubra* and *Cypripedium reginae* are found in the prairie. *Thuja occidentalis* as well as *C. reginae* are found in the wet forest.

The slopes of the bowl are primarily composed of Oshtemo sandy loam, an inorganic soil that is moderately well-drained. The pH of the slopes is slightly more acidic than the pH of the prairie or the tamarack swamp. The calcium and magnesium content of the slopes is markedly less than in the wet forest, tamarack swamp, or prairie (Table 1), indicating leaching of calcium and magnesium from the slopes to the floor of the bowl and the tamarack swamp. The south-facing slope has much less calcium and magnesium than the north- or west-facing slopes. This variation may be due to the difference in leaf litter composition as the south-facing slope has more oaks present than either the north- or west-facing slopes. The high amount of potassium on the west-facing slope may be due to runoff from Hochberger Road and from surrounding fields which have been fertilized.

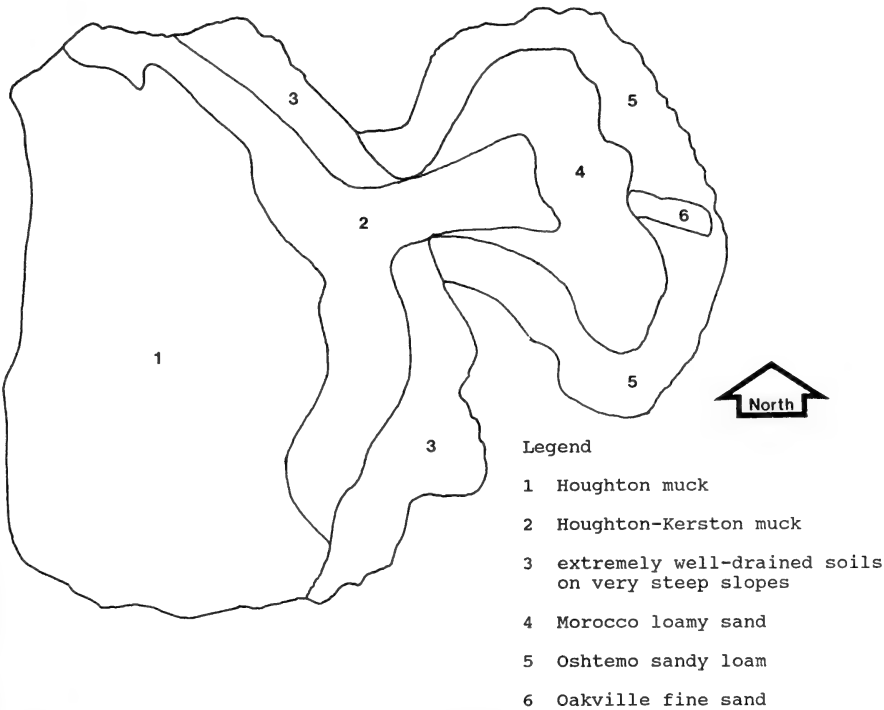


Figure 5. Soils of the Indian Bowl study area (adapted from Larson 1980).

# DESCRIPTION OF THE VEGETATION

## METHODS

The quadrat or plot method (Brower & Zar 1977) was used to sample the prairie and the herbaceous vegetation of the floor and the slopes of the bowl. The position of 0.25 $m^2$ plots along transects was determined using a random numbers table (Brower & Zar 1977). The percent cover was estimated for each species in each plot. Values of relative dominance and relative frequency were calculated from the plot data. Importance values were calculated by taking the mean ($\bar{x}$) of the relative values. A species-area curve was used to determine the proper number of sampling points necessary to accurately represent the composition of the communities being sampled (Cox 1976).

The prairie vegetation was analyzed by samples taken at two different times. In mid-July 1980, 102 plots were sampled along 1000 meters of transect. The transect was oriented in a northeast-southwest line beginning at the southern end of the prairie. At the end of August 1981, 83 plots along 800 meters of transect with the same orientation as the July sample were taken.

Fourteen randomly placed 1 $m^2$ permanent plots were also used to sample the prairie at five different times during the growing season of 1981. Cover estimates were recorded for each species in each of the 14 plots in May, at the beginning and end of June, in mid-July, and mid-September. Relative dominance and relative frequency values were calculated using the same techniques as described in the sampling methods above.

In the analysis of the herbaceous spring flora of the bowl, sixteen plots were sampled

Table 1. Concentrations of eight macro- and micro-nutrients of the soils of the wet prairie, tamarack swamp, and the floor and slopes of the bowl.

| COMMUNITY | pH | MACRO-NUTRIENTS Phosphorus P (kg/ha) | Potassium K (kg/ha) | Calcium Ca (kg/ha) | Magnesium Mg (kg/ha) | MICRO-NUTRIENTS Iron Fe (ppm) | Zinc Zn (ppm) | Manganese Mn (ppm) | Copper Cu (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| Wet prairie | 6.8 | 6.7 | 62.6 | 8049.6 | 1403.1 | 8 | 6 | 24 | 6 |
| Tamarack Swamp | 6.9 | 7.8 | 98.4 | 10221.9 | 1508.2 | 4 | 6 | 30 | 6 |
| Bowl Floor | 6.3 | 11.8 | 152.1 | 10221.9 | 1456.8 | 12 | 24 | 67 | 7 |
| North-facing bowl slope | 6.2 | 31.3 | 161.0 | 3465.8 | 488.6 | 16 | 8 | 40 | 1 |
| West-facing bowl slope | 6.2 | 64.8 | 251.6 | 3465.8 | 578.0 | 20 | 8 | 43 | 1 |
| South-facing bowl slope | 6.5 | 102.9 | 161.0 | 1900.6 | 345.5 | 16 | 7 | 38 | 3 |

along the north-facing slope, 15 along the west-facing, 17 along the south-facing slope, and 21 plots from the floor of the bowl.

The point-quarter method (Cottam & Curtis 1956) was used to sample the arborescent vegetation of the tamarack swamp and the bowl. The position of the points along each of the transects was determined using a random number table (Brower & Zar 1977). A species-area curve was used to determine the optimum number of sampling points (Cox 1976). Trees 2.5 cm (one inch) dbh (diameter at breast height) or greater were recorded. Values of relative dominance, relative density, and relative frequency were calculated from the data. Importance values were calculated by taking the mean ($\bar{x}$) of the relative values.

The tamarack swamp was sampled in January 1981. Fifty-two points were sampled along 300 meters of transect placed in a northwest-southeast line beginning at the southern end of the swamp.

Within the bowl two transects were placed on each of the northern, western, and southern aspects of the slopes perpendicular to the contour of the slope. One transect was placed in a northwest-southeast line through the central portion of the bowl floor. Sixty-eight points were sampled in March 1981 along 600 meters of transect on the slopes and 43 points were sampled along 500 meters of transect on the bowl floor.

## WET PRAIRIE

## RESULTS

The vegetation of the wet prairie changes in structure and composition throughout the growing season. Plots taken in July indicate that the prairie is co-dominated by *Carex* and *Solidago* (Table 2). Seven of the 33 taxa encountered comprise almost 90 percent of the vegetation cover. Plots taken at the end of August indicate that the prairie then had no single dominant or co-dominant but that *Solidago, Carex,* and *Sorghastrum nutans* make up 50 percent of the cover (Table 2). At the end of August, the number of taxa which comprise 90 percent of the vegetation cover of the prairie had increased to eleven. Comparison of the taxa encountered in July and August shows that 50 percent are common to both samples. The most important change in the prairie from the July to August samples is the death of much of the *Carex* and the increase in the cover of *Solidago* and *Sorghastrum nutans. Filipendula rubra* and *Thelypteris palustris* maintain their relative importance as sub-dominants in the prairie throughout the season. (The position of *F. rubra* as a subdominant in prairies in Ohio has been noted by Jones (1944).) Taxa which exhibit little change in dominance are *Boehmeria cylindrica, Convolvulus sepium, Iris virginica, Rhamnus alnifolius,* and *Silphium integrifolium.*

The seasonal change in the vegetation structure of the prairie may also be seen in the results of the permanent plot samples. The plots were sampled five times from May to September. While the total number of species encountered increased from eight in May to 17 in September (Table 3), six species were encountered throughout the season. *Carex* is dominant in May, but decreases in importance through July as the dominance of *Solidago* and *Eupatorium* increases. From July to September the dominance of *Carex* drops sharply and the importance and number of composites (Asteraceae)

Table 2. Results of the plot sample of the wet prairie taken July 12, 1980 and August 30, 1981.

| Species | Relative Dominance | | Relative Frequency | | Importance Value | |
|---|---|---|---|---|---|---|
| | Jul | Aug | Jul | Aug | Jul | Aug |
| *Solidago* spp. | 18.2 | 21.9 | 21.5 | 15.8 | 19.9 | 18.9 |
| *Carex* spp. | 44.1 | 15.7 | 21.2 | 12.5 | 32.6 | 14.1 |
| *Sorghastrum nutans* | – | 11.2 | – | 7.3 | – | 9.3 |
| *Thelypteris palustris* | 7.8 | 5.5 | 11.4 | 10.2 | 9.6 | 7.8 |
| *Eupatorium maculatum* | 1.3 | 8.5 | 3.4 | 5.9 | 2.3 | 7.2 |
| *Filipendula rubra* | 7.2 | 6.8 | 8.0 | 5.9 | 7.6 | 6.3 |
| *Thalictrum dasycarpum* | 3.6 | 5.3 | 6.3 | 5.9 | 5.0 | 5.6 |
| *Spartina pectinata* | 0.0 | 5.6 | 0.2 | 3.1 | 0.1 | 4.3 |
| *Oxypolis rigidior* | 0.4 | 2.2 | 1.5 | 4.5 | 0.9 | 3.4 |
| *Aster* spp. | – | 2.9 | – | 3.1 | – | 3.0 |
| *Andropogon gerardii* | – | 2.6 | – | 2.1 | – | 2.4 |
| *Lathyrus palustris* | 0.3 | 1.0 | 2.2 | 3.6 | 1.2 | 2.3 |
| *Calamagrostis canadensis* | 3.6 | 1.7 | 2.7 | 2.4 | 3.1 | 2.0 |
| *Zizia aurea* | 0.5 | 1.6 | 1.0 | 2.1 | 0.7 | 1.9 |
| *Galium obtusum* | 0.1 | 1.5 | 0.5 | 2.1 | 0.3 | 1.8 |
| *Iris virginica* | 0.6 | 0.5 | 2.2 | 2.6 | 1.4 | 1.5 |
| *Convolvulus sepium* | 0.7 | 0.5 | 3.1 | 2.4 | 1.9 | 1.4 |
| *Vernonia missurica* | 0.1 | 0.7 | 0.2 | 1.4 | 0.2 | 1.1 |
| *Eupatorium perfoliatum* | 0.6 | 0.3 | 1.9 | 1.0 | 1.3 | 0.6 |
| *Boehmeria cylindrica* | 0.4 | 0.2 | 1.5 | 1.0 | 0.9 | 0.6 |
| *Salix sericea* | 0.3 | 0.9 | 0.2 | 0.2 | 0.3 | 0.6 |
| *Allium cernuum* | – | 0.2 | – | 1.0 | – | 0.6 |
| *Pedicularis lanceolata* | – | 0.2 | – | 0.7 | – | 0.5 |
| *Silphium integrifolium* | 0.4 | 0.4 | 0.2 | 0.5 | 0.3 | 0.4 |
| *Rhamnus alnifolius* | 0.2 | 0.6 | 0.5 | 0.2 | 0.4 | 0.4 |
| *Onoclea sensibilis* | 2.0 | 0.4 | 1.2 | 0.2 | 1.6 | 0.3 |
| *Parnassia glauca* | – | 1.0 | – | 0.5 | – | 0.3 |
| *Agrimonia pubescens* | – | 0.3 | – | 0.2 | – | 0.3 |
| *Helianthus giganteus* | – | 0.3 | – | 0.2 | – | 0.3 |
| *Cirsium muticum* | – | 0.1 | – | 0.5 | – | 0.3 |
| *Cicuta maculata* | – | 0.3 | – | 0.2 | – | 0.3 |
| *Panicum virgatum* | – | 0.1 | – | 0.2 | – | 0.2 |
| *Apios americana* | – | 0.1 | – | 0.2 | – | 0.2 |
| *Sagittaria cuneata* | 0.3 | 0.0 | 0.5 | 0.2 | 0.4 | 0.1 |
| *Bromus ciliatus* | 5.7 | – | 4.4 | – | 5.0 | – |
| *Anemone canadensis* | 0.2 | – | 1.2 | – | 0.7 | – |
| *Cornus foemina* | 0.3 | – | 0.7 | – | 0.5 | – |
| *Smilacina stellata* | 0.2 | – | 0.5 | – | 0.3 | – |
| *Lysimachia ciliata* | 0.1 | – | 0.5 | – | 0.3 | – |
| *Symplocarpus foetidus* | 0.3 | – | 0.2 | – | 0.3 | – |
| *Impatiens pallida* | 0.2 | – | 0.2 | – | 0.2 | – |
| *Viburnum lentago* | 0.2 | – | 0.2 | – | 0.2 | – |
| *Acer rubrum* | 0.1 | – | 0.2 | – | 0.2 | – |
| *Ribes cynosbati* | 0.0 | – | 0.2 | – | 0.1 | – |
| *Rumex orbiculatus* | 0.0 | – | 0.2 | – | 0.1 | – |

increases. Thus, in May the most important component of the prairie is *Carex*, but by September *Solidago* and *Eupatorium* are co-dominant.

## DISCUSSION

Both transect and permanent plot samples indicate that the prairie has a prolonged blooming time which results in a changing vegetational structure in the span of one growing season. This can be seen by the increase in the number of species encountered from the beginning to the end of the season and by their changing importance in the prairie during that time. The prairie as a whole may be characterized as a community which is dominated throughout the season by three families: Asteraceae, Cyperaceae, and Poaceae, which shift in their relative importance from May to September and thus provide a dynamic aspect to the structure of the vegetation. For a more detailed discussion of what constitutes a wet prairie see Kron (1982).

Most of the species encountered in the Indian Bowl wet prairie are perennials and the prairie has an abundance of vegetative cover. However, the number of individuals which flower in any one growing season is quite small. The great amount of dead grasses and sedges and the low frequency of flowering individuals suggest that this prairie has not burned for many years. Controlled burning of the wet prairie would be important for three reasons. First, it would remove the mat of dead grasses and sedges and therefore open up new spaces for seed germination. Secondly, the burning would inhibit the spread of *Cornus, Viburnum,* and other shrubs presently invading the prairie. Lastly, controlled burning often increases the percentage of individuals which flower in the following season (Kohring 1982). Burning would thus deter the development of wet prairie into shrub carr and increase the possibility of further establishment of wet-mesic and prairie species already present in the Indian Bowl site.

## TAMARACK SWAMP

## RESULTS

The results of the sampling of the tamarack swamp show that tamarack (*Larix laricina*) is the dominant species and *Acer rubrum* and *Fraxinus nigra* are subdominant (Table 4). Tamarack individuals vary in age from saplings to old trees over 38 cm. in diameter (Fig. 6). The swamp also contains several understory species as well as some small individuals of species typical of southern hardwood forests (Sytsma & Pippen 1982).

Table 3. Results of the permanent plot samples of the wet prairie taken May, June 12 & 27, July and September.

| | Relative Dominance | | | | | Relative Frequency | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | May | Jun1 | Jun2 | Jul | Sep | May | Jun1 | Jun2 | Jul | Sep |
| *Solidago* spp. | 30.6 | 31.5 | 40.2 | 34.8 | 46.9 | 28.0 | 25.0 | 23.7 | 14.5 | 15.6 |
| *Eupatorium* spp. | — | 0.1 | 0.1 | 6.6 | 18.3 | — | 1.8 | 3.4 | 14.5 | 13.3 |
| *Carex* spp. | 53.9 | 45.9 | 42.7 | 40.5 | 8.2 | 28.0 | 25.0 | 23.7 | 16.9 | 15.6 |
| *Aster* spp. | — | — | — | — | 6.7 | — | — | — | — | 12.2 |
| *Thelypteris palustris* | 0.6 | 4.6 | 1.4 | 6.6 | 3.8 | 12.0 | 14.3 | 10.2 | 16.9 | 14.4 |
| *Calamagrostis canadensis* | 13.7 | 16.6 | 10.1 | 7.4 | 11.2 | 18.0 | 16.1 | 11.9 | 8.4 | 6.7 |
| *Iris virginica* | 0.9 | 0.6 | 0.5 | 0.7 | 0.5 | 8.0 | 7.1 | 8.5 | 8.4 | 5.6 |
| *Lathyrus palustris* | 0.2 | — | — | — | 1.0 | 2.0 | — | — | — | 3.3 |
| *Boehmeria cylindrica* | — | — | 0.1 | 0.2 | 1.1 | — | — | 1.7 | 1.2 | 2.2 |
| *Galium obtusum* | — | — | 0.1 | 0.9 | 0.8 | — | — | 1.7 | 4.8 | 2.2 |
| *Convolvulus sepium* | — | 0.2 | 0.4 | 0.5 | 0.3 | — | 1.8 | 3.4 | 3.6 | 2.2 |
| *Asclepias syriaca* | — | 0.2 | 3.9 | 0.4 | 0.5 | — | 1.8 | 3.4 | 1.2 | 1.1 |
| *Agrimonia pubescens* | — | — | — | — | 0.2 | — | — | — | — | 1.1 |
| *Chelone glabra* | — | — | — | — | 0.1 | — | — | — | — | 1.1 |
| *Lysimachia ciliata* | — | — | 0.1 | 0.1 | 0.1 | — | — | 1.7 | 1.2 | 1.1 |
| *Oxypolis rigidior* | 0.1 | 0.3 | 0.4 | 0.6 | 0.1 | 2.0 | 3.6 | 5.1 | 2.4 | 1.1 |
| *Elymus virginicus* | — | — | 0.1 | — | 0.1 | — | — | 1.7 | — | 0.1 |
| *Parthenocissus quinquefolia* | 0.1 | — | — | — | — | 2.0 | — | — | — | — |
| *Sagittaria cuneata* | — | 0.1 | — | — | — | — | 1.8 | — | — | — |
| *Agrostis* spp. | — | 0.0 | — | — | — | — | 1.8 | — | — | — |
| *Bromus ciliatus* | — | — | — | 0.3 | — | — | — | — | 1.2 | — |

| Species | Importance Value May | Jun1 | Jun2 | Jul | Sep |
|---|---|---|---|---|---|
| *Solidago* spp. | 29.3 | 28.4 | 32.0 | 24.6 | 31.3 |
| *Eupatorium* spp. | – | 0.9 | 1.7 | 10.5 | 15.8 |
| *Carex* spp. | 41.0 | 35.5 | 33.2 | 28.7 | 11.8 |
| *Aster* spp. | – | – | – | – | 9.5 |
| *Thelypteris palustris* | 6.3 | 9.5 | 5.8 | 11.8 | 9.1 |
| *Calamagrostis canadensis* | 15.9 | 16.3 | 11.0 | 7.9 | 8.9 |
| *Iris virginica* | 4.5 | 3.9 | 4.5 | 4.6 | 3.1 |
| *Lathyrus palustris* | 1.1 | – | – | – | 2.2 |
| *Boehmeria cylindrica* | – | – | 0.9 | 0.7 | 1.7 |
| *Galium obtusum* | – | – | 0.9 | 2.9 | 1.5 |
| *Convolvulus sepium* | – | 1.0 | 1.9 | 2.1 | 1.3 |
| *Asclepias syriaca* | – | 1.0 | 3.7 | 0.8 | 0.8 |
| *Agrimonia pubescens* | – | – | – | – | 0.7 |
| *Chelone glabra* | – | – | – | – | 0.6 |
| *Lysimachia cilata* | – | – | 0.9 | 0.6 | 0.6 |
| *Oxypolis rigidior* | 1.1 | 1.9 | 2.7 | 1.5 | 0.6 |
| *Elymus virginicus* | – | – | 0.9 | – | 0.6 |
| *Parthenocissus quinquefolia* | 1.1 | – | – | – | – |
| *Sagittaria cuneata* | – | 0.9 | – | – | – |
| *Agrostis* spp. | – | 0.9 | – | – | – |
| *Bromus ciliatus* | – | – | – | 0.8 | – |

Table 4. Results of the point-quarter sample of the tamarack swamp

| Species | Relative Dominance | Relative Density | Relative Frequency | Importance Value |
|---|---|---|---|---|
| *Larix laricina* | 47.4 | 28.3 | 22.9 | 32.8 |
| *Acer rubrum* | 22.4 | 11.7 | 12.1 | 15.4 |
| *Lindera benzoin* | 1.3 | 14.6 | 16.4 | 10.8 |
| *Fraxinus nigra* | 13.3 | 7.3 | 7.9 | 9.5 |
| *Viburnum lentago* | 1.6 | 12.2 | 12.1 | 8.7 |
| *Toxicodendron vernix* | 2.7 | 10.2 | 10.7 | 7.9 |
| *Ulmus americana* | 4.9 | 5.4 | 5.7 | 5.3 |
| *Cornus alternifolia* | 1.1 | 3.9 | 3.6 | 2.9 |
| *Prunus serotina* | 0.8 | 1.5 | 2.1 | 1.5 |
| *Carpinus caroliniana* | 0.4 | 2.0 | 2.1 | 1.5 |
| *Liriodendron tulipifera* | 2.6 | 0.5 | 0.7 | 1.3 |
| *Betula alleghaniensis* | 1.2 | 1.0 | 2.4 | 1.2 |
| *Quercus bicolor* | 0.2 | 0.5 | 0.7 | 0.5 |
| *Tilia americana* | 0.1 | 0.5 | 0.7 | 0.4 |
| *Prunus virginiana* | 0.0 | 0.5 | 0.7 | 0.4 |

## DISCUSSION

Succession in tamarack forests in southern Michigan leads to size-structured forest in the later stages of development (Sytsma & Pippen 1982). Within this structure, a relatively few large individuals of tamarack dominate an understory mainly composed of young individuals of *Acer rubrum, Toxicodendron vernix,* and tamarack. The Indian Bowl tamarack swamp appears to be intermediate between the mature and late stages of tamarack forest succession due to the presence of a few large individuals of *L. laricina* which dominate the swamp and the comparatively low density of *L. laricina* saplings (Sytsma & Pippen 1982). However, the importance of *Acer rubrum* and *Fraxinus nigra* may indicate the early stage of transition to southern hardwood forest. Transition from tamarack swamp to hardwood forest has been described in the later stages of development by Kurz (1923) and Brewer (1966), where broad-leaved species dominate and tamarack is of little importance. The transition from tamarack forest to hardwoods is considered rapid in undisturbed situations (Sytsma & Pippen 1982), but Brewer (1966) states that these forests in southwestern Michigan rarely remain undisturbed long enough to allow succession to hardwood forest to continue.

The Indian Bowl area exhibits little evidence of disturbance by fire or man. This is indicated by the many *Larix laricina* saplings around the edge of the forest and the presence of a few large individuals in the middle of the wet prairie. No fire scars have been observed on the trees in the tamarack forest. The thriving *Cornus* and *Viburnum* thickets presently invading the wet prairie also support this, as both are also sensitive to fire. The lack of development between the moraine and the tamarack swamp has prevented

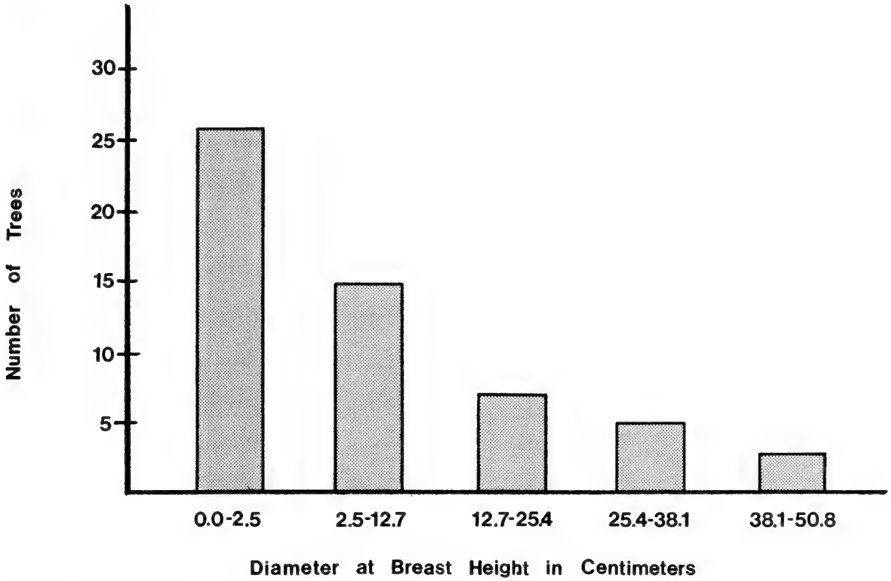


Figure 6. Size class distribution of *Larix laricina* (tamarack).

any significant change in drainage or water level to which tamaracks are sensitive (Sytsma & Pippen 1982). Therefore, an important factor in the continuing succession of the tamarack swamp has been its particularly isolated location within the Indian Bowl site.

## SPRING FLORA OF THE SLOPES AND FLOOR OF THE BOWL

### RESULTS

The results of the sampling of the herbaceous spring flora of the slopes and floor of the bowl (Table 5) show that *Smilacina racemosa* and *Trillium grandiflorum* are the most important species in May. *Smilacina* is the most important on the north- and south-facing slopes of the bowl with *Osmorhiza claytonii* of secondary importance on the north-facing and *Hydrophyllum appendiculatum* of secondary importance on the south-facing slope. On the floor and the west-facing slope of the bowl, *Trillium grandiflorum* is the most important species with *Viola canadensis* following in importance on the west-facing slope and *Geranium maculatum* of secondary importance on the floor of the bowl. Three species were encountered on all three slopes and the floor of the bowl: *Trillium grandiflorum, Smilacina racemosa,* and *Polygonatum pubescens.*

Table 5. Results of the plot sample of the herbaceous spring flora of the floor and slopes of the bowl.

| | Relative Dominance | | | | Relative Frequency | | | | Importance Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Facing Slope | | | | Facing Slope | | | | Facing Slope | | | |
| Species | N | W | S | Floor | N | W | S | Floor | N | W | S | Floor |
| *Asarum canadense* | – | – | 11.8 | – | – | – | 11.5 | – | – | – | 11.6 | – |
| *Caulophyllum thalictroides* | 9.1 | – | 1.3 | 1.5 | 3.6 | – | 7.7 | 2.0 | 6.3 | – | 4.4 | 1.7 |
| *Dicentra canadensis* | – | 0.5 | – | 4.3 | – | 2.8 | – | 6.1 | – | 1.6 | – | 5.2 |
| *Galium aparine* | 3.5 | 6.7 | – | 1.2 | 7.1 | 5.6 | – | 4.1 | 5.3 | 6.1 | – | 2.6 |
| *Geranium maculatum* | – | 13.1 | – | 6.8 | – | 11.1 | – | 16.3 | – | 12.1 | – | 13.5 |
| *Hepatica acutiloba* | – | – | 2.6 | – | – | – | 3.9 | – | – | – | 3.2 | – |
| *Hydrophyllum appendiculatum* | – | 11.7 | 29.5 | 7.7 | – | 13.9 | 19.2 | 8.2 | – | 12.8 | 24.3 | 7.9 |
| *Osmorhiza claytonii* | 21.3 | 9.9 | – | 5.1 | 17.9 | 13.9 | – | 8.2 | 19.6 | 11.9 | – | 9.6 |
| *Panax trifolius* | 2.6 | – | – | – | 7.1 | – | – | – | 4.9 | – | – | – |
| *Podophyllum peltatum* | – | – | 13.6 | 13.3 | – | – | 11.5 | 6.1 | – | – | 12.5 | 9.7 |
| *Polygonatum pubescens* | 1.7 | 1.4 | 1.0 | 1.0 | 3.6 | 5.6 | 3.9 | 2.0 | 2.6 | 3.4 | 2.5 | 1.5 |
| *Smilacina racemosa* | 50.9 | 13.1 | 33.9 | 9.4 | 35.7 | 13.9 | 30.8 | 8.2 | 43.3 | 13.4 | 32.3 | 8.9 |
| *Stylophorum diphyllum* | 4.8 | – | – | – | 17.9 | – | – | – | 11.3 | – | – | – |
| *Trillium grandiflorum* | 6.1 | 35.1 | 6.4 | 44.6 | 7.1 | 11.1 | 11.5 | 16.3 | 6.6 | 23.1 | 9.0 | 30.4 |
| *Viola canadensis* | – | 8.1 | – | 5.3 | – | 19.4 | – | 16.3 | – | 13.8 | – | 10.8 |
| *V. pubescens* | – | 0.5 | – | – | – | 2.8 | – | – | – | 1.6 | – | – |

Table 6. Results of the point-quarter sample of the floor of the bowl

| Species | Relative Dominance | Relative Density | Relative Frequency | Importance Value |
|---|---|---|---|---|
| *Carpinus caroliniana* | 5.5 | 25.3 | 20.9 | 17.2 |
| *Lindera benzoin* | 1.1 | 15.8 | 14.8 | 10.6 |
| *Ostrya virginiana* | 3.7 | 11.9 | 11.0 | 8.9 |
| *Liriodendron tulipifera* | 19.5 | 2.0 | 2.8 | 8.1 |
| *Acer saccharum* | 5.8 | 7.9 | 7.7 | 7.1 |
| *Platanus occidentalis* | 17.0 | 1.6 | 1.7 | 6.7 |
| *Tilia americana* | 4.0 | 5.5 | 6.6 | 5.4 |
| *Populus deltoides* | 10.8 | 1.6 | 2.2 | 4.9 |
| *Fraxinus nigra* | 4.4 | 4.4 | 5.0 | 3.5 |
| *Prunus virginiana* | 5.2 | 4.4 | 3.9 | 4.5 |
| *Asimina triloba* | 0.7 | 4.7 | 5.0 | 3.5 |
| *Fagus grandifolia* | 8.2 | 0.8 | 1.1 | 3.4 |
| *Ulmus rubra* | 2.2 | 4.0 | 3.9 | 3.3 |
| *Aesculus glabra* | 2.2 | 2.4 | 3.3 | 2.6 |
| *Fraxinus pennsylvanica* | 3.7 | 1.6 | 2.2 | 2.5 |
| *Ulmus americana* | 2.5 | 1.2 | 1.7 | 1.8 |
| *Acer rubrum* | 1.9 | 1.2 | 1.1 | 1.4 |
| *Celtis occidentalis* | 1.3 | 0.4 | 0.6 | 0.8 |
| *Acer negundo* | 0.3 | 0.8 | 1.1 | 0.7 |
| *Crataegus* sp. | 0.1 | 0.8 | 1.1 | 0.7 |
| *Viburnum prunifolium* | 0.1 | 0.8 | 1.1 | 0.7 |
| *Hamamelis virginiana* | 0.1 | 0.8 | 1.1 | 0.7 |
| *Staphylea trifolia* | 0.1 | 0.4 | 0.6 | 0.3 |

## DISCUSSSION

Comparison of the species found on each slope and the floor of the bowl indicates that north- and south-facing slopes are the least similar, with only three species common to both slopes. The north- and west-facing slopes are most similar with five species common to both slopes. However, each slope aspect has more species in common with the floor of the bowl than with any of the other slope exposures, possibly because of the larger number of species found on the floor of the bowl. The greater diversity on the floor of the bowl may be due to the greater amount of the light available because of lack of continuous tree cover.

## TREES OF THE BOWL FLOOR

## RESULTS

Twenty-three species were encountered in the sample of the bowl floor. In this wet forest, typical understory species are more important than canopy species. *Carpinus caroliniana* is the most important tree (Table 6) with *Lindera benzoin* and *Ostrya virginiana* also very common. Typical canopy species of bottomlands or wet sites, *Liriodendron tulipifera, Platanus occi-*

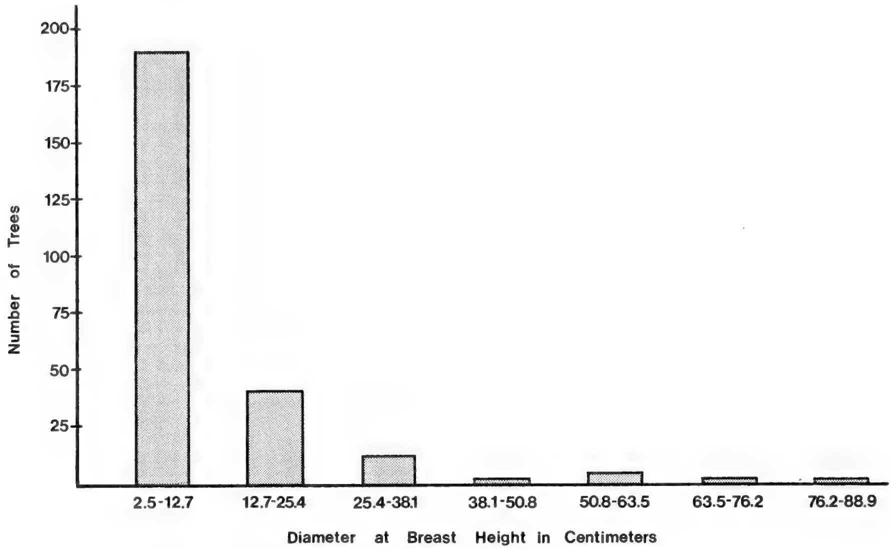


Figure 7. Size class distribution of trees sampled in the floor of the bowl.

*dentalis,* and *Populus deltoides* (Harlow & Harrar 1958), are infrequent in the forest and do not form a continuous cover of vegetation above the *Carpinus.* The wet nature of the forest is also indicated by the presence of *Fraxinus nigra, F. pennsylvanica, Acer rubrum,* and *Celtis occidentalis.* Over 75 percent of the trees encountered were 2.5 to 12.7 cm in diameter. None of the trees sampled were larger than 50.8 cm dbh (Fig. 7).

The forest on the bowl floor has some species in common with the tamarack swamp and with the slopes of the bowl. *Acer rubrum* and *Fraxinus nigra* are also found in the tamarack swamp (Table 4) but there they are larger in size and more frequent than on the floor of the bowl. *Ostrya* and *Carpinus* are found on both the slopes and the bowl floor but *Carpinus* is much less frequent on the slopes while *Ostrya* is an important understory tree but is smaller in size than on the floor of the bowl. Five species occurred on the bowl floor but were not encountered in either the tamarack swamp or on the slopes of the bowl: *Acer negundo, Crataegus* sp., *Fraxinus pennsylvanica, Staphylea trifolia,* and *Aesculus glabra.*

## TREES ON THE SLOPES OF THE BOWL

## RESULTS

Results of the point-quarter sampling of trees on the slopes of the bowl show differences in the composition and structure of the vegetation depending on the slope aspect. The most important species on the west- and north-

facing slopes is *Acer saccharum* (Table 7). On the north-facing slope, *A. saccharum* is generally larger in size than on the west-facing slope. *Liriodendron tulipifera* is the second most important species on the north-facing slope while *Fagus grandifolia* is the second most important species on the west-facing slope. On the south-facing slope, however, *Quercus alba* is the most important species. On this slope, oaks (*Q. alba, Q. rubra,* and *Q. macrocarpa*) comprise over 50 percent of the cover. Differences among the slopes may also be seen in the composition and importance of the understory species on the south-facing slope.

Using Sorensen's index of similarity based on the presence or absence of species (Mueller-Dombois & Ellenberg 1974), the west- and north-facing slopes of the bowl were the most similar (Table 8) and the north- and south-facing slopes were the least similar.

## DISCUSSION

Differences in composition and structure of the vegetation among slopes of varying aspects have often been studied (Armesto & Martinez 1978; Geiger 1950; Shanks & Norris 1950; Spurr 1964). Studies comparing north-facing and south-facing slopes in eastern North America have included vegetational differences as well as differences in insolation and soil temperature (Cantlon 1953; Cooper 1961; Pearson 1971; Shanks & Norris 1950). The Indian Bowl depression with its steeply-sloping sides offers another example of differences in the composition and structure of the vegetation based on topography. One of the most important differences between north- and south-facing slopes is the amount of insolation each receives during the day. The northern exposure receives the least amount of direct sunlight and is therefore cooler and moister than the south-facing slope which receives a greater amount of the direct sunlight and is dryer and warmer (Geiger 1950). This difference in the microclimate is also reflected in the composition and structure of the vegetation. The species composition at the Indian Bowl site is similar on all slopes but the structure; i.e., dominance, density, and frequency varies according to slope aspect.

The greater importance of *Liriodendron tulipifera* on the north-facing slope of the bowl than on the south-facing slope indicates the cooler, moister nature of the northern exposure. *Liriodendron tulipifera* is favored on moist sites (Harlow & Harrar 1958). The greater importance of *Liriodendron* on north-facing slopes has also been documented in other eastern North American studies (Cantlon 1953; Pearson 1971; Shanks & Norris 1950). The dominance of oaks on the south-facing slopes of the bowl and the importance of *Cornus florida* as an understory species is typical of south-facing slopes in eastern North America (Cantlon 1953; Pearson 1971; Shanks & Norris 1950). Thus, the bowl-formation exhibits typical differences in species composition and vegetational structure due to slope exposure when compared to other studies of the effect of slope aspect on the vegetation in eastern North America.

Table 7. Results of the point-quarter sample the slopes of the bowl.

| Species | Relative Dominance Facing Slope | | | Relative Density Facing Slope | | | Relative Frequency Facing Slope | | | Importance Value Facing Slope | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | W | S | N | W | S | N | W | S | N | W | S |
| *Acer rubrum* | — | — | 5.1 | — | — | 4.0 | — | — | 3.5 | — | — | 4.2 |
| *A. saccharum* | 20.0 | 10.4 | 7.9 | 31.9 | 41.9 | 7.9 | 25.9 | 32.5 | 8.8 | 26.0 | 28.3 | 8.2 |
| *Asimina triloba* | 0.8 | 0.8 | — | 9.7 | 1.6 | — | 3.7 | 2.5 | — | 4.7 | 1.4 | — |
| *Carpinus caroliniana* | — | 0.8 | — | — | 3.2 | — | — | 2.5 | — | — | 2.2 | — |
| *Carya cordiformis* | 3.8 | — | — | 2.8 | — | — | 1.9 | — | — | 2.8 | — | — |
| *Celtis occidentalis* | — | — | 1.0 | — | — | 5.3 | — | — | 5.3 | — | — | 3.9 |
| *Cornus florida* | — | 0.1 | 0.6 | — | 1.6 | 15.8 | — | 2.5 | 14.0 | — | 1.4 | 15.4 |
| *Fagus grandifolia* | 17.2 | 43.9 | 6.2 | 6.9 | 11.3 | 9.2 | 7.4 | 8.8 | 8.8 | 10.5 | 21.3 | 8.1 |
| *Fraxinus americana* | 14.4 | 24.1 | 14.8 | 5.6 | 4.8 | 1.3 | 7.4 | 6.2 | 1.8 | 9.1 | 11.7 | 6.0 |
| *Hamamelis virginiana* | 0.1 | 0.0 | 0.5 | 2.8 | 0.8 | 14.5 | 3.7 | 1.3 | 14.0 | 2.2 | 0.7 | 9.7 |
| *Lindera benzoin* | — | — | 0.1 | — | — | 5.3 | — | — | 3.5 | — | — | 3.0 |
| *Liriodendron tulipifera* | 25.7 | 0.1 | 0.1 | 11.1 | 0.8 | 1.3 | 13.0 | 1.3 | 1.8 | 16.6 | 0.7 | 1.0 |
| *Ostrya virginiana* | 2.5 | 0.4 | 0.2 | 12.5 | 4.8 | 4.0 | 14.8 | 7.5 | 3.5 | 9.9 | 4.3 | 2.5 |
| *Prunus serotina* | 0.1 | 13.7 | — | 1.4 | 11.3 | — | 1.9 | 11.3 | — | 1.1 | 12.1 | — |
| *Quercus alba* | — | 2.6 | 25.1 | — | 2.4 | 10.5 | — | 3.8 | 10.5 | — | 2.9 | 15.4 |
| *Q. macrocarpa* | — | — | 12.5 | — | — | 2.6 | — | — | 3.5 | — | — | 6.2 |
| *Q. rubra* | 4.2 | — | 21.7 | 2.8 | — | 2.6 | 3.7 | — | 3.5 | 3.6 | — | 9.3 |
| *Robinia pseudo-acacia* | — | — | 1.0 | — | — | 1.3 | — | — | 1.8 | — | — | 1.4 |
| *Sassafras albidum* | 3.8 | 1.3 | 3.0 | 2.8 | 0.8 | 7.9 | 3.7 | 1.3 | 8.8 | 3.4 | 1.1 | 6.6 |
| *Tilia americana* | 1.5 | — | — | 1.4 | — | — | 1.9 | — | — | 1.6 | — | — |
| *Ulmus americana* | 6.1 | 2.2 | — | 6.9 | 9.7 | — | 9.3 | 11.3 | — | 7.4 | 7.7 | — |
| *U. rubra* | — | 0.1 | 0.1 | — | 2.4 | 2.6 | — | 3.8 | 3.5 | — | 2.1 | 2.1 |
| *Viburnum prunifolium* | 0.0 | 0.1 | 0.1 | 1.4 | 2.4 | 4.0 | 1.9 | 3.8 | 3.5 | 1.1 | 2.1 | 2.5 |

Table 8. Index of similarity values for the north-, west-, and south-facing slopes of the bowl.

| West-facing/ North-facing | North-facing/ South-facing | South-facing/ West-facing |
|---|---|---|
| 75.86 | 58.06 | 68.75 |

## SUMMARY

The Indian Bowl tract comprises diverse community types and a unique landform. The wet, organic soils of the prairie, tamarack swamp, and bowl floor are frequently flooded and calcium rich. The occurrence of calciphilic species such as *Cypripedium reginae* and *Thuja occidentalis* are noticeable evidence of the latter. The wet prairie is dominated by *Carex* in early spring, but by late summer *Solidago* and *Eupatorium* are co-dominant. *Filipendula rubra* and *Thelypteris palustris* are relatively stable in their importance as subdominants throughout the growing season. The tamarack swamp is dominated by *Larix laricina,* with *Acer rubrum* and *Fraxinus nigra* subdominant. It is the least diverse of the forest vegetation within the Indian Bowl tract. Of the fifteen species encountered in the sample of the tamarack swamp, seven are also found in the bowl floor (*Acer rubrum, Carpinus caroliniana, Fraxinus nigra, Lindera benzoin, Liriodendron tulipifera, Tilia americana,* and *Ulmus americana*). All of these species are characteristic of wet or floodplain vegetation.

The well-drained, and sometimes very steep, slopes of the bowl support tree species common in southwestern Michigan. The north- and west-facing slopes are most similar in species composition, both for the trees as well as the herbaceous spring flora. *Acer saccharum* is the most important woody species on these slopes. By contrast, the south-facing slope of the bowl is dominated by oaks and *Cornus florida* is an important understory species.

Within the study area, some state threatened or special concern (rare) plants are common or even abundant. Some of the most noticeable are *Filipendula rubra, Polemonium reptans, Silphium integrifolium,* and *Trillium recurvatum.* However, the relative abundance of these species could very easily be diminished if this area is not protected.

The extensive wet prairie, the large bowl-shaped depression, the importance of threatened and special concern (rare) species throughout the area, and the undisturbed nature of the site are primary factors in making the Indian Bowl tract unique in Michigan. Hopefully, the study of the vegetation of this area can contribute towards its ultimate conservation.

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# THE VEGETATION OF INDIAN BOWL WET PRAIRIE AND ITS ADJACENT PLANT COMMUNITIES

## II. CHECKLIST OF VASCULAR PLANTS

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A previous paper (Kron 1989) has discussed the soils and vegetation of the Indian Bowl wet prairie and its adjacent plant communities. Presented here is a checklist of the vascular plants occurring in the study area.

The checklist includes a primary set of voucher specimens deposited in the University of Michigan Herbarium (MICH), with duplicates deposited in the Beal-Darlington Herbarium of Michigan State University (MSC), and the Herbarium of Andrews University (AUB), in Berrien Springs, Michigan, unless otherwise noted. Species recorded in this checklist are documented by previous collections or were collected by the author during the spring, summer, and fall of 1980–1981, and the spring of 1982. In a few cases species were recorded which were observed by the author, but not collected. A permit was obtained through the Michigan Department of Natural Resources to collect state threatened plants. Although more species have been previously listed from this area (Medley 1972), part of the difference in number is due to the size of the study area for this project, which is somewhat smaller than the area inventoried earlier by Medley (1972). Thus many weedy species found along the stream and field to the south of Love Creek are not included in the checklist. Three of the species previously listed should be noted. *Phlox maculata* L. has been reported, but investigation by the author indicates that no one has yet seen it in the area. *Cypripedium calceolus* var. *parviflorum* (Salisb.) Fern. is reported from the woods at the base of the moraine; this is not a usual habitat for this variety (Fernald 1950) and it was not found during the course of this study. Only one individual of *Cypripedium candidum* Willd. was found during the study; it was not collected but is included in the checklist.

The checklist is arranged using Cronquist's (1981) system of classification for the dicotyledons and the monocotyledons. The pteridophytes and gymnosperms are arranged according to Gleason and Cronquist (1963). Scientific and common names follow that of Gleason and Cronquist (1963) for the ferns and fern allies, Voss (1972) for the monocots and gymnosperms, and Voss (1985) for the dicots, excluding the Cucurbitaceae, Pri-

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mulaceae, and the Asteridae, which follow Gleason and Cronquist (1963). Nomenclature for *Dryopteris celsa* (W. Palmer) Small and *Rudbeckia sullivantii* Boyton & Beadle follows that of Fernald (1950). Threatened or special concern status was determined according to Beaman et al. (1985).

The checklist includes 84 families and 218 genera. There are 323 species; 309 are native, 14 are introduced. Eight families have ten or more species in the study area. The Asteraceae have the highest number of species with 39, and the Poaceae have the next highest with 29. The largest genus is *Solidago* with 9 species; *Carex* has 8 species. Most of the introduced species were found along the path through the prairie or along the road that follows the base of the slopes of the bowl.

## CHECKLIST OF VASCULAR PLANTS

### LYCOPODIOPHYTA (Clubmosses)

LYCOPODIACEAE

*Lycopodium lucidulum* Michaux, Clubmoss—*Kron 869* (AUB, MICH, MSC), along bank of north-facing slope of the bowl.

SELAGINELLACEAE

*Selaginella apoda* (L.) Spring, Selaginella—*Kron 652* (AUB, MICH, MSC), along foot path in wet prairie.

### POLYPODIOPHYTA (Ferns)

OPHIOGLOSSACEAE

*Botrychium virginianum* (L.) Sw., Rattlesnake fern—*Kron 815, 958* (both at AUB, MICH, MSC), common on floor of bowl.

OSMUNDACEAE

*Osmunda regalis* L., Royal fern—*Kron 820* (AUB, MSC), in tamarack swamp between wet prairie and the bowl.

POLYPODIACEAE

*Adiantum pedatum* L., Maidenhair fern—*Kron 814* (AUB, MICH, MSC), south end of bowl, wooded slope.

*Athyrium filix-femina* (L.) Roth, Ladyfern—*Kron 799* (AUB, MICH, MSC), at eastern end of the bowl, rich wooded slope.

*A. thelypteroides* (Michaux) Desv.—*Kron 842* (MICH, MSC), at eastern end of bowl, wooded slope.

*Cystopteris bulbifera* (L.) Bernh., Bladder fern—*Kron 835* (MICH, MSC), wooded slopes at base of the moraine, south of the gap in the bowl.

*Dryopteris celsa* (W. Palmer) Small, Log fern—*Wagner 74233* (MICH), *Medley s.n.* (MICH), near gap of bowl.

*Onoclea sensibilis* L., Sensitive fern—*Kron 873* (AUB, MICH, MSC), common in wet prairie and in thickets.

*Polystichum acrostichoides* (Michaux) Schott, Christmas fern—*Kron 808* (AUB, MICH, MSC), south end of bowl, wooded slope.

*Thelypteris palustris* Schott, Marsh fern—*Kron 687, 841* (both at AUB, MICH, MSC), common throughout wet prairie.

PINOPHYTA (Gymnosperms)

CUPRESSACEAE

*Thuja occidentalis* L., Arbor vitae—*Kron 959* (AUB, MICH, MSC), in gap of the bowl, along stream.

PINACEAE

*Larix laricina* (Duroi) K. Koch, Tamarack—*Kron 618* (AUB, MICH, MSC), tree to 60 ft., dominant in swamp along eastern edge of wet prairie.

MAGNOLIOPHYTA (Angiosperms)
MAGNOLIOPSIDA (Dicotyledons)
MAGNOLIIDAE

MAGNOLIACEAE

*Liriodendron tulipifera* L., Tulip-poplar—*Kron 966* (AUB, MICH, MSC), common in floor of bowl and on the north- and west-facing slopes of the bowl.

ANNONACEAE

*Asimina triloba* (L.) Dunal, Pawpaw—*Kron 749* (AUB, MICH, MSC), small tree, common on slopes of the bowl, in thickets between the tamarack swamp and the bowl.

LAURACEAE

*Lindera benzoin* (L.) Blume, Spicebush—*Kron 715* (AUB, MICH, MSC), small tree, common in thicket between tamarack swamp and the bowl.

*Sassafras albidum* (Nutt.) Nees, Sassafras—*Kron 953* (AUB, MICH, MSC), tree to 5 meters, on slope of bowl.

ARISTOLOCHIACEAE

*Asarum canadense* L., Wild-ginger—*Kron 812* (AUB, MICH, MSC), south end of bowl, wooded slope.

RANUNCULACEAE

*Actaea pachypoda* Elliott, White baneberry—*Kron 761* (MICH), *803* (MICH, MSC), *954* (AUB, MSC), floor of bowl.

*Anemone canadensis* L., Canada anemone—*Kron 600* (AUB, MICH, MSC), throughout wet prairie.

*Anemonella thalictroides* (L.) Spach, Rue-anemone—*Kron 724* (AUB, MICH, MSC), rich woods, loamy soil at base of moraine.

*Aquilegia canadensis* L., Wild columbine—*Kron 748* (AUB, MICH, MSC), along road at base of moraine, sandy soil.

*Caltha palustris* L., Marsh-marigold—*Kron 713* (AUB, MICH, MSC), common along creeks.

*Clematis virginiana* L., Virgin's bower—*Kron 690* (AUB, MICH, MSC), twining vine, southern part of prairie.

*Hepatica acutiloba* DC., Hepatica—*Kron 733* (AUB, MICH, MSC), on steeply sloping sides of bowl, loamy sand.

*H. americana* (DC.) Ker Gawler, Hepatica—*Kron 738* (AUB, MSC), south-facing slope of bowl, steeply sloping, sandy.

*Isopyrum biternatum* (Raf.) Torrey & A. Gray, False rue-anemone—*Kron 719* (AUB, MICH, MSC), in very wet soil in thickets at edge of wet prairie.

*Ranunculus abortivus* L., Small-flowered buttercup—*Kron 969* (AUB, MICH, MSC), floor of bowl.

*R. hispidus* Michaux, Swamp buttercup—*Kron 599, 717, 753* (all at AUB, MICH, MSC), floor of bowl at gap.

*R. recurvatus* Poiret, Hooked crowfoot—*Kron 757, 970* (both at AUB, MICH, MSC), slope of bowl, eastern end.

*Thalictrum dasycarpum* Fischer & Avé-Lall., Purple meadow-rue—*Kron 605* (AUB, MICH, MSC), common in wet prairie.

*T. dioicum* L., Early meadow-rue—*Kron 737* (AUB, MICH, MSC), south-facing slope, sandy soil.

BERBERIDACEAE

*Caulophyllum thalictroides* (L.) Michaux, Blue cohosh—*Kron 734* (AUB, MICH, MSC), south side of bowl, steep slope, loamy sand.

*Podophyllum peltatum* L., May-apple—*Kron 760* (AUB, MICH, MSC), floor of bowl.

PAPAVERACEAE

*Chelidonium majus* L., Celandine—*Kron 762* (AUB, MICH, MSC), along road through south end of bowl, introduced from Europe.

*Sanguinaria canadensis* L., Bloodroot—*Kron 709* (AUB, MICH, MSC), rich loamy sand, south side of bowl.

*Stylophorum diphyllum* (Michaux) Nutt., Wood poppy—*Kron 727* (AUB, MICH, MSC), very steeply sloping, south side of bowl, loamy sand.

FUMARIACEAE

*Corydalis flavula* (Raf.) DC., Yellow harlequin—*Smith s.n.* (AUB), uncommon.

*Dicentra canadensis* (Goldie) Walp., Squirrel-corn—*Kron 728* (AUB, MICH, MSC), south side of bowl on a very steep slope, loamy sand.

*D. cucullaria* (L.) Bernh., Dutchman's-breeches—*Kron 730* (AUB, MICH, MSC), south side of bowl on steep slope, loamy sand.

HAMAMELIDAE

PLATANACEAE

*Platanus occidentalis* L., Sycamore—*Kron pers. obs.*, bowl floor.

HAMAMELIDACEAE

*Hamamelis virginiana* L., Witch-hazel—*Kron 951* (AUB, MICH, MSC), slopes of the bowl.

CANNABACEAE

*Humulus lupulus* L., Hops—*Kron 837* (AUB, MICH, MSC), climbing vine in thickets between tamarack swamp and bowl, from Europe.

ULMACEAE

*Celtis occidentalis* L., Hackberry—*Kron pers. obs.*, bowl floor and south-facing slope of bowl.

*Ulmus americana* L., American elm—*Kron pers. obs.*, bowl floor, north- and west-facing slopes of bowl.

*U. rubra* Muhlenb., Slippery elm—*Kron pers. obs.*, bowl floor, west- and south-facing slopes of bowl.

URTICACEAE

*Boehmeria cylindrica* (L.) Sw., False nettle—*Kron 668* (AUB, MICH, MSC), in wet prairie.

*Laportea canadensis* (L.) Wedd., Wood nettle—*Kron 899* (AUB, MICH, MSC), wooded floor of the bowl.

*Pilea pumila* (L.) A. Gray, Clearweed—*Kron 849* (AUB, MSC), along road south end of bowl, base of steep slope.

FAGACEAE

*Fagus grandifolia* Ehrh., Beech—*Kron 952* (AUB, MICH, MSC), on slopes of bowl.

*Quercus alba* L., White oak—*Kron pers. obs.*, south-facing slope of bowl.

*Q. bicolor* Willd., Swamp white oak—*Kron pers. obs.*, tamarack swamp.

*Q. macrocarpa* Michaux, Bur oak—*Kron pers. obs.*, south-facing slope of bowl.

*Q. rubra* L., Red oak—*Kron pers. obs.*, north- and south-facing slopes of bowl.

JUGLANDACEAE

*Carya cordiformis* (Wangenh.) K. Koch, Bitternut hickory—*Kron 967* (MICH, MSC), on slopes of bowl.

BETULACEAE

*Betula alleghaniensis* Britton, Yellow birch—*Kron pers. obs.*, tamarack swamp.

*B. pumila* L., Dwarf birch—*Kron 617* (AUB, MICH, MSC), small shrub in wet prairie.

*Carpinus caroliniana* Walter, Blue-beech—*Kron 961* (AUB, MICH, MSC), floor of bowl.

*Ostrya virginiana* (Miller) K. Koch, Ironwood—*Kron 968* (AUB, MICH, MSC), slopes of bowl.

## CARYOPHYLLIDAE

PHYTOLACCACEAE

*Phytolacca americana* L., Pokeweed—*Kron 875* (AUB, MICH, MSC), along path through bowl, sandy soil.

PORTULACACEAE

*Claytonia virginica* L., Spring-beauty—*Kron 720* (AUB, MSC), in wet soil along edge of thickets, and the wet prairie.

POLYGONACEAE

*Polygonum persicaria* L., Heart's-ease—*Kron 850* (MICH, MSC), along stream running through prairie, introduced from Europe.

*P. virginianum* L., Jumpseed—*Kron 870* (MICH, MSC), south end of bowl, base of slope.

*Rumex orbiculatus* A. Gray, Great water dock—*Kron 641* (MICH), *673* (MICH, MSC), edge of creek running through prairie.

## DILLENIIDAE

CLUSIACEAE

*Hypericum punctatum* Lam., Spotted St. John's-wort—*Kron 847* (AUB, MICH, MSC), open spot on floor of bowl.

TILIACEAE

*Tilia americana* L., Basswood—*Kron 974* (AUB, MICH, MSC), scattered through bowl.

VIOLACEAE

*Viola arvensis* Murray, Field pansy—*Kron 756* (MICH), slope of bowl, eastern end, introduced from Europe.

*V. canadensis* L., Canada violet—*Kron 731* (AUB, MICH, MSC), south side of bowl, steep slope.

*V. conspersa* Reichb., Dog violet—*Kron 723* (AUB, MICH, MSC), rich woods, loamy sand at base of moraine.

*V. cucullata* Aiton, Marsh violet—*Kron 722* (AUB, MICH, MSC), wet soil, edges of prairie.

*V. pubescens* Aiton, Yellow violet—*Kron 711* (AUB, MSC), south-facing slope of bowl, loamy sand.

CUCURBITACEAE

*Echinocystis lobata* (Michaux) Torrey & A. Gray, Wild cucumber—*Kron 683* (AUB, MICH, MSC), climbing vine in woods along river.

SALICACEAE

*Populus deltoides* Marshall, Cottonwood—*Kron pers. obs.*, bowl floor.

*Salix discolor* Muhlenb., Pussy willow—*Kron 754* (AUB, MSC), floor of bowl at gap.

*S. petiolaris* Smith, Meadow willow—*Kron 927* (AUB, MICH, MSC), forming thickets with *Cornus*.

*S. sericea* Marshall, Silky willow—*Kron 642* (MICH), *653* (AUB, MSC), *708* (AUB, MICH, MSC), forming thickets with *Cornus*, along banks of Love Creek.

BRASSICACEAE

*Arabis laevigata* (Muhlenb.) Poiret, Rock cress—*Kron 790* (AUB, MICH, MSC), eastern end of bowl, rich wooded slopes.

*Cardamine bulbosa* (Muhlenb.) BSP., Spring cress—*Kron 781* (AUB, MICH, MSC), wet soil in thickets, and scattered through prairie.

*C. douglassii* Britton, Pink spring cress—*Kron 718* (AUB, MICH, MSC), wet soil in thickets.

*Dentaria diphylla* Michaux, Two-leaved toothwort—*Kron 747* (AUB, MICH, MSC), south side of bowl, at base of slope.

*Nasturtium officinale* R. Br., Watercress—*Kron 597* (AUB, MICH, MSC), rooted in bottom of sluggish stream in prairie, introduced from Europe.

PRIMULACEAE

*Lysimachia ciliata* L., Loosestrife—*Kron 670* (AUB, MSC), *801* (MICH), wet prairie.

*L. nummularia* L., Moneywort—*Kron 666* (AUB, MSC), along edge of stream in prairie, from Europe.

*L. quadriflora* Sims, Loosestrife—*Kron 654* (AUB, MICH, MSC), in prairie.

*L. terrestris* (L.) BSP., Loosestrife—*Kron 649* (AUB, MICH, MSC), wet prairie.

ROSIDAE

GROSSULARIACEAE

*Ribes cynosbati* L., Prickly gooseberry—*Kron 710* (AUB, MICH, MSC), shrub, rich woods, floor of bowl.

SAXIFRAGACEAE

*Mitella diphylla* L., Bishop's-cap—*Kron 626* (AUB, MSC), *726* (AUB, MICH, MSC), tamarack swamp, thickets, slopes of the bowl.

*Parnassia glauca* Raf., Grass-of-Parnassus—*Kron 914* (AUB, MICH, MSC), southern portion of prairie.

*Saxifraga pensylvanica* L., Swamp saxifrage—*Kron 604* (MICH), *783* (AUB, MICH, MSC), along streams running through the prairie.

ROSACEAE

*Agrimonia gryposepala* Wallr., Agrimony—*Kron 640* (MICH), wet prairie.

*A. parviflora* Aiton, Agrimony—*Kron 700* (AUB, MICH, MSC), occasional in wet prairie.

*A. pubescens* Wallr., Agrimony—*Kron 853* (AUB, MICH, MSC), floor of bowl, wooded.

*Amelanchier laevis* Wieg., Serviceberry—*Kron 714* (AUB, MICH, MSC), small tree, at edge of tamarack swamp and prairie.

*Aronia prunifolia* (Marshall) Rehder, Chokeberry—*Kron 776* (AUB, MSC), *957* (AUB, MICH, MSC), southeast portion of prairie at edge of tamarack swamp.

*Filipendula rubra* (Hill) Robinson, Queen-of-the-prairie—*Kron 645* (AUB, MICH, MSC), *Gillis 13935* (MSC), abundant in prairie.

*Fragaria virginiana* Miller, Wild strawberry—*Kron 771* (AUB, MICH, MSC), southeast portion of prairie.

*Geum canadense* Jacq., Avens—*Kron 809* (AUB, MICH, MSC), south end of bowl, wooded slope.

*G. rivale* L., Avens—*Kron 778* (MICH), in shade under *Cornus*, one seen.

*Potentilla fruticosa* L., Shrubby cinquefoil—*Kron 696* (AUB, MICH, MSC), shrub, southeast portion of prairie.

*P. recta* L., Rough-fruited cinquefoil—*Kron 791* (MICH), eastern end of bowl, introduced from Europe.

*Prunus serotina* Ehrh., Wild black cherry—*Kron pers. obs.*, slopes of the bowl.

*P. virginiana* L., Choke cherry—*Kron 777* (AUB, MICH, MSC), in tamarack swamp and bowl.

*Rubus occidentalis* L., Black raspberry—*Kron 960* (AUB, MICH, MSC), thicket between tamarack swamp and bowl.

*R. pubescens* Raf., Dwarf raspberry—*Kron 774* (AUB, MICH, MSC), *964* (AUB, MSC), edge of tamarack swamp and prairie, and thickets between tamarack swamp and bowl.

CAESALPINIACEAE

*Cercis canadensis* L., Redbud—*Kron 751* (AUB, MICH, MSC), small tree, floor of bowl.

FABACEAE

*Amphicarpaea bracteata* (L.) Fern., Hog-peanut—*Kron 905* (AUB, MICH, MSC), thickets, twining vine.

*Apios americana* Medikus, Groundnut—*Kron 681* (AUB, MICH, MSC), twining vine in wet prairie.

*Desmodium nudiflorum* (L.) DC., Tick-trefoil—*Kron 833* (AUB, MICH, MSC), *887* (AUB, MSC), thickets.

*D. paniculatum* (L.) DC., Tick-trefoil—*Kron 891* (MICH, MSC), wooded slopes of the bowl.

*Lathyrus palustris* L., Marsh pea—*Kron 619* (AUB, MICH, MSC), twining herb, throughout prairie.

*Robinia pseudo-acacia* L., Black locust—*Kron 962* (AUB, MICH, MSC), occasional on floor and slopes of bowl.

LYTHRACEAE

*Lythrum alatum* Pursh, Loosestrife—*Kron 828* (AUB, MICH, MSC), central prairie, south portion.

ONAGRACEAE

*Circaea lutetiana* L., Enchanter's-nightshade—*Kron 807* (AUB, MICH, MSC), south end of bowl, base of wooded slope.

*Epilobium coloratum* Biehler, Willow-herb—*Kron 680* (AUB, MSC), *880* (AUB, MICH, MSC), in wetter spots in prairie.

*Gaura biennis* L., Gaura—*Kron 675* (AUB, MICH, MSC), along creek running through prairie.

*Oenothera biennis* L., Evening-primrose—*Kron 885* (AUB, MICH, MSC), along road at base of moraine, south of gap in bowl.

CORNACEAE

*Cornus alternifolia* L.f., Alternate-leaved dogwood—*Kron pers. obs.*, tamarack swamp.

*Cornus amomum* Miller, Pale dogwood—*Kron 872* (AUB, MICH, MSC), forming thickets along stream banks.

*C. florida* L., Flowering dogwood—*Kron 745* (AUB, MSC), small tree, floor of bowl.

*C. foemina* subsp. *racemosa* (Lam.) J.S. Wilson, Gray dogwood—*Kron 608* (AUB, MICH, MSC), shrub to 7 ft., forming thickets along edge of prairie.

*C. stolonifera* Michaux, Red-osier—*Kron 956* (AUB, MICH, MSC), occasional spreading shrub in prairie.

RHAMNACEAE

*Rhamnus alnifolia* L'Hér., Alder-leaved buckthorn—*Kron 620* (AUB, MICH, MSC), small shrub, occasional in prairie.

VITACEAE

*Parthenocissus quinquefolia* (L.) Planchon, Virginia creeper—*Kron pers. obs.*, prairie.

*Vitis riparia* Michaux, River-bank grape—*Kron 976* (AUB, MICH, MSC), leaning, twining vine on *Cornus* in prairie.

POLYGALACEAE

*Polygala senega* L., Seneca snakeroot—*Kron 595* (AUB, MICH, MSC), wet prairie.

STAPHYLEACEAE

*Staphylea trifolia* L., Bladdernut—*Kron 764* (AUB, MICH, MSC), floor of bowl.

HIPPOCASTANACEAE

*Aesculus glabra* Willd., Ohio buckeye—*Kron 750* (AUB, MICH, MSC), common throughout bowl, and in thickets.

ACERACEAE

*Acer negundo* L., Box-elder—*Kron 972* (AUB, MICH, MSC), eastern end of bowl, slopes, and on floor.

*A. rubrum* L., Red maple—*Kron pers. obs.*, bowl floor.

*A. saccharum* Marshall, Sugar maple—*Kron 955, 975* (both at AUB, MICH, MSC), in bowl where it forms an important component of the woods.

ANACARDIACEAE

*Toxicodendron vernix* (L.) Kuntze, Poison sumac—*Kron 935* (AUB, MICH, MSC), prairie, tamarack swamp, and thickets.

RUTACEAE

*Ptelea trifoliata* L., Hop-tree—*Kron 832* (AUB, MICH, MSC), thickets between tamarack swamp and moraine.

OXALIDACEAE

*Oxalis stricta* L., Wood-sorrel—*Kron 800* (AUB, MICH, MSC), along road, east end of bowl.

GERANIACEAE

*Geranium maculatum* L., Wild geranium—*Kron 765* (AUB, MICH, MSC), floor of bowl.

LIMNANTHACEAE

*Floerkea proserpinacoides* Willd., False mermaid—*Kron 735* (AUB, MICH, MSC), forming mats on north-facing slope of bowl.

BALSAMINACEAE

*Impatiens pallida* Nutt., Pale touch-me-not—*Kron 804, 854* (both at AUB, MICH, MSC), southeast end of bowl, and floor.

ARALIACEAE

*Panax trifolius* L., Dwarf ginseng—*Kron 712* (AUB, MICH, MSC), along road through the floor of bowl.

APIACEAE

*Angelica atropurpurea* L., Angelica—*Kron 616* (AUB, MICH, MSC), large herb to 6 ft., wet prairie.

*Berula erecta* (Hudson) Cov.—*Kron 858* (AUB, MICH, MSC), *Medley s.n.* (MOR), *Schaddalee 59-80* (MSC), decumbent, emergent from sluggish stream in prairie.

*Chaerophyllum procumbens* (L.) Crantz, Wild-chervil—*Kron 767* (AUB, MICH, MSC), western edge of prairie, near St. Joseph River.

*Cicuta maculata* L., Water hemlock—*Kron 664* (AUB, MICH, MSC), occasional in prairie.

*Cryptotaenia canadensis* (L.) DC., Honewort—*Kron 864* (MSC), thickets between prairie and bowl.

*Osmorhiza claytonii* (Michaux) C. B. Clarke, Sweet-cicely—*Kron 784* (AUB, MICH, MSC), *843* (MICH, MSC), thickets on edge of prairie.

*O. longistylis* (Torrey) DC., Sweet-cicely—*Kron 759* (AUB, MICH, MSC), slope of bowl, eastern end.

*Oxypolis rigidior* (L.) Raf., Cowbane—*Kron 693* (AUB, MICH, MSC), common in wet prairie.

*Sanicula gregaria* Bickn., Black snakeroot—*Kron 813* (AUB, MICH, MSC), south end of bowl, wooded slope.

*Zizia aurea* (L.) Koch, Golden alexanders—*Kron 593* (AUB, MICH, MSC), abundant in wet prairie.

## ASTERIDAE

### GENTIANACEAE

*Gentiana andrewsii* Griseb., Closed gentian—*Kron 703* (AUB, MICH, MSC), *949* (AUB, MSC), wet prairie.

*G. procera* Holm, Gentian—*Kron 705, 706* (both at AUB, MSC), *948* (AUB, MICH, MSC), wet prairie.

*Swertia caroliniensis* (Walter) Kuntze, American columbo—*Kron 785* (AUB, MICH, MSC), south-facing slope at gap of bowl, base of slope, sandy.

### APOCYNACEAE

*Apocynum sibiricum* Jacq., Indian hemp—*Kron 627* (AUB, MICH, MSC), wet prairie north of main creek.

### ASCLEPIADACEAE

*Asclepias incarnata* L., Swamp-milkweed—*Kron 650* (AUB, MICH, MSC), occasional in wet prairie.

*A. purpurascens* L., Milkweed—*Kron 817* (AUB, MICH, MSC), occasional in south end of prairie.

*A. syriaca* L., Milkweed—*Kron 665* (AUB, MICH, MSC), occasional in prairie.

### SOLANACEAE

*Solanum dulcamara* L., Bittersweet—*Kron 816* (AUB, MICH, MSC), along edge of creek, prairie.

*S. dulcamara* f. *albiflorum* House—*Kron 614* (AUB, MICH, MSC), along edge of creek in the prairie, from Europe.

### CONVOLVULACEAE

*Convolvulus sepium* L., Hedge bindweed—*Kron 607* (AUB, MSC), climbing vine, prairie.

### CUSCUTACEAE

*Cuscuta gronovii* Willd., Dodder—*Kron 679* (AUB, MICH, MSC), parasitic herb growing on *Epilobium coloratum* in creek in prairie.

### POLEMONIACEAE

*Phlox divaricata* L., Phlox—*Kron 752* (AUB, MICH, MSC), floor of bowl at gap and in thickets between the tamarack swamp and the bowl.

*Polemonium reptans* L., Jacob's ladder—*Kron 601* (AUB, MICH, MSC), *755* (MSC), throughout the wet prairie, in thickets, and floor of bowl. Threatened in Michigan.

### HYDROPHYLLACEAE

*Hydrophyllum appendiculatum* Michaux, Water-leaf—*Kron 971* (AUB, MICH, MSC), slope of bowl.

*H. canadense* L., Water-leaf—*Kron 806* (AUB, MICH, MSC), south end of bowl, wooded slope.

*H. virginianum* L., Water-leaf—*Kron 977* (AUB, MICH, MSC), slope of bowl.

VERBENACEAE

*Phryma leptostachya* L., Lopseed—*Kron 830* (MICH), *902* (AUB, MICH, MSC), wooded slopes of bowl.

*Verbena hastata* L., Vervain—*Kron 698* (AUB, MSC), wet prairie.

*V. urticifolia* L., Vervain—*Kron 865* (AUB, MICH, MSC), woods and floor of bowl.

LAMIACEAE

*Blephila hirsuta* (Pursh) Benth.—*Kron 851* (AUB, MICH, MSC), floor of bowl.

*Glecoma hederacea* L., Ground-ivy—*Kron 770* (AUB, MSC), west edge of prairie, along St. Joseph River, from Europe.

*Lamium amplexicaule* L., Dead nettle—*Kron 769* (AUB, MSC), western edge of prairie, along St. Joseph river, near woods, from Europe.

*Leonurus cardiaca* L., Motherwort—*Kron 795* (AUB, MICH, MSC), eastern end of bowl, base of wooded slope, along road, Eurasian.

*Lycopus americanus* Muhlenb., Water-horehound—*Kron 689* (AUB, MICH, MSC), wet prairie.

*L. uniflorus* Michaux, Water-horehound—*Kron 697* (AUB, MICH, MSC), wet prairie.

*Mentha arvensis* L., Mint—*Kron 859* (MICH), *922* (MSC), prairie.

*Monarda fistulosa* L., Horse-mint—*Kron 663* (AUB, MICH, MSC), north side of creek, prairie.

*Prunella vulgaris* L., Self-heal—*Kron 655* (AUB, MSC), along footpath in the prairie, introduced from Europe.

*Pycnanthemum virginianum* (L.) T. Durand & B. D. Jackson, Mountain-mint—*Kron 677* (AUB, MICH, MSC), south portion of prairie.

*Satureja vulgaris* (L.) Fritsch, Wild basil—*Kron 793* (AUB, MICH, MSC), eastern end of bowl, base of wooded slope, along road.

*Scutellaria galericulata* L., Skullcap—*Kron 648* (AUB, MSC), *684* (MICH), prairie.

*S. lateriflora* L., Skullcap—*Kron 848* (AUB, MICH, MSC), along road through south end of bowl.

*Stachys tenuifolia* Willd., Hedge-nettle—*Kron 915* (MICH), prairie.

*Teucrium canadense* L., Wood-sage—*Kron 838* (AUB, MICH, MSC), edge of floor of bowl.

OLEACEAE

*Fraxinus americana* L., White ash—*Kron 973* (AUB, MSC), large tree in floor and slopes of bowl.

*F. nigra* Marshall, Black ash—*Kron pers. obs.*, tamarack swamp and bowl floor.

*F. pennsylvanica* Marshall—*Kron pers. obs.*, bowl floor.

SCROPHULARIACEAE

*Chelone glabra* L., Turtlehead—*Kron 917* (AUB, MICH, MSC), throughout prairie.

*Gerardia purpurea* L.—*Kron 916* (MICH, MSC), prairie.

*Pedicularis canadensis* L., Lousewort—*Kron 746* (AUB, MICH, MSC), floor of bowl.

*P. lanceolata* Michaux, Lousewort—*Kron 921* (AUB, MICH, MSC), throughout prairie.

*Scrophularia marilandica* L., Figwort—*Kron 852* (AUB, MICH, MSC), along path around base of bowl.

*Veronica officinalis* L., Speedwell—*Kron 846* (AUB, MICH, MSC), south edge of floor, open spot, wet soil, introduced from Europe.

*Veronicastrum virginicum* (L.) Farw., Culver's root—*Kron 678* (AUB, MICH, MSC), south of main creek, prairie.

OROBANCHACEAE

*Conopholis americana* (L.) Wallr., Squaw-root—*Kron 787* (AUB, MICH, MSC), south-facing slope of bowl, sandy soil, parasitic.

*Epifagus virginiana* (L.) Barton, Beech-drops—*Kron 938* (AUB, MICH, MSC), wooded slope of bowl, parasitic.

CAMPANULACEAE

*Campanula aparinoides* Pursh, Marsh-bellflower—*Kron 651* (AUB, MICH, MSC), wet prairie.

*C. rotundifolia* L., Harebell—*Kron 811* (AUB, MICH, MSC), base of moraine, steep slope.

*Lobelia inflata* L., Indian tobacco—*Kron 845* (AUB, MICH, MSC), base of slopes, north end of bowl.

*L. siphilitica* L., Lobelia—*Kron 694* (AUB, MICH, MSC), prairie.

RUBIACEAE

*Galium aparine* L., Bedstraw—*Kron 768* (AUB, MICH, MSC), along St. Joseph river.

*G. asprellum* Michaux, Bedstraw—*Kron 878* (AUB, MICH, MSC), prairie.

*G. circaezans* Michaux, Bedstraw—*Kron 789* (AUB, MSC), *868* (AUB, MICH, MSC), prairie.

*G. labradoricum* (Weig.) Weig., Bedstraw—*Kron 782* (AUB, MICH, MSC), prairie.

*G. obtusum* Bigelow, Bedstraw—*Kron 606* (AUB, MICH, MSC), prairie.

CAPRIFOLIACEAE

*Lonicera dioica* L., Wild honeysuckle—*Kron 779* (MICH, MSC), climbing vine on *Cornus*, wet prairie.

*Sambucus canadensis* L., Common elder—*Kron 667* (AUB, MICH, MSC), tall shrub, south of main creek, prairie.

*S. pubens* Michaux, Red-berried elder—*Kron 729* (AUB, MICH, MSC), very steep slope, north-facing.

*Viburnum acerifolium* L., Arrow-wood—*Kron 786* (AUB, MICH, MSC), north end of bowl, small shrub in sandy soil.

*V. lentago* L., Sheepberry—*Kron 638* (MICH), shrub, forming thickets along stream.

*V. prunifolium* L., Black haw—*Kron pers. obs.*, floor and slopes of bowl.

ASTERACEAE

*Antennaria plantaginifolia* (L.) Richardson, Pussy-toes—*Kron 740* (AUB, MICH, MSC), north slope, sandy.

*Aster cordifolius* L., Aster—*Kron 936* (AUB, MICH, MSC), prairie.

*A. lateriflorus* (L.) Britton, Aster—*Kron 941* (AUB, MICH, MSC), prairie.

*A. lucidulus* (A. Gray) Weig., Aster—*Kron 944* (AUB, MSC), prairie.

*A. macrophyllus* L., Aster—*Kron 890* (AUB, MSC), *892* (AUB, MICH, MSC), floor of bowl.

*A. novae-angliae* L., Aster—*Kron 946* (AUB, MICH, MSC), prairie

*A. puniceus* L., Aster—*Kron 939* (AUB, MSC), *947* (AUB, MICH, MSC), wooded slopes of bowl.

*A. simplex* Willd., Aster—*Kron 923* (AUB, MICH, MSC), prairie.

*A. umbellatus* Miller, Aster—*Kron 912* (AUB, MSC), *919* (AUB, MICH, MSC), prairie.

*Cirsium muticum* Michaux, Thistle—*Kron 671* (MICH, MSC), prairie.

*Erigeron annuus* (L.) Pers., Fleabane—*Kron 894* (AUB, MSC), prairie.

*E. philadelphicus* L., Fleabane—*Kron 797* (AUB, MICH, MSC), eastern end of bowl.

*Eupatorium maculatum* L., Joe-Pye weed—*Kron 686* (AUB, MSC), *910* (AUB, MICH, MSC), prairie.

*E. perfoliatum* L., Boneset—*Kron 701* (AUB, MICH, MSC), wet prairie.

*E. rugosum* Houtt., White snakeroot—*Kron 844* (MICH), *893* (AUB, MICH, MSC), south edge of the floor of the bowl.

*Helenium autumnale* L., Sneezeweed—*Kron 913* (AUB, MICH, MSC), wet prairie.

*Helianthus giganteus* L., Sunflower—*Kron 882, 920* (both at AUB, MICH, MSC), prairie.

*Heliopsis helianthoides* (L.) Sweet, Ox-eye—*Kron 659* (AUB, MSC), *907* (AUB, MICH, MSC), semi-shaded area along creek, prairie.

*Hieracium paniculatum* L., Hawkweed—*Kron 888* (AUB, MICH, MSC), in sandy path through floor of bowl.

*Lactuca canadensis* L., Lettuce—*Kron 861* (MICH), sandy soil in path of bowl.

*Liatris spicata* (L.) Willd., Blazing star—*Kron 691* (AUB, MICH, MSC), southeast prairie.

*Polymnia canadensis* L., Leaf-cup—*Kron 836* (AUB, MICH, MSC), along road through south end of bowl.

*Prenanthes alba* L., White lettuce—*Kron 896* (AUB, MICH, MSC), prairie.

*P. racemosa* Michaux, White lettuce—*Kron 943* (AUB, MICH, MSC), wet prairie.

*Rudbeckia hirta* L., Black-eyed Susan—*Kron 656* (AUB, MICH, MSC), southernmost portion of prairie.

*R. sullivantii* Boynton & Beadle, Showy black-eyed Susan—*Kron 682* (AUB, MSC), common in southern portion of prairie. Special concern in Michigan.

*Senecio aureus* L., Groundsel—*Kron 596, 741* (AUB, MICH, MSC), edges of creeks in wet prairie and floor of bowl.

*Silphium integrifolium* Michaux, Rosin-weed—*Kron 661* (AUB, MICH, MSC), *Gillis & Kohring 14167* (MSC), scattered throughout prairie.

*Solidago canadensis* L., Goldenrod—*Kron 881* (MICH, MSC), *883, 925* (both at MSC), *934* (AUB, MSC), prairie.

*S. caesia* L., Goldenrod—*Kron 903* (AUB, MICH, MSC), wooded slopes at base of moraine.

*S. flexicaulis* L., Goldenrod—*Kron 895* (MICH, MSC), *937* (AUB, MICH, MSC), prairie.

*S. gigantea* Aiton, Goldenrod—*Kron 688* (AUB, MSC), *900* (AUB, MICH, MSC), wet prairie.

*S. graminifolia* (L.) Salisb., Goldenrod—*Kron 908* (AUB, MICH, MSC), *924* (MSC), prairie.

*S. hispida* Muhlenb., Goldenrod—*Kron 898* (MICH), prairie.

*S. patula* × *S. uliginosa* Nutt., Goldenrod—*Kron 933* (MICH), prairie.

*S. riddellii* Frank, Goldenrod—*Kron 940* (AUB, MICH, MSC), prairie.

*S. uliginosa* Nutt., Goldenrod—*Kron 932* (MSC), *942, 945* (both at MICH), prairie.

*Verbesina alternifolia* (L.) Britton, Wingstem—*Kron 879* (AUB, MICH, MSC), prairie.

*Vernonia missurica* Raf., Ironweed—*Kron 676* (AUB, MICH, MSC), prairie.

## LILIOPSIDA (Monocotyledons)
## ALISMATIDAE

### ALISMATACEAE

*Sagittaria cuneata* Sheldon, Arrowhead—*Kron 702* (MICH, MSC), *911* (MSC), wetter spots of prairie and thickets.

### JUNCAGINACEAE

*Triglochin palustre* L., Arrow-grass—*Kron 860* (AUB, MICH, MSC), in small pool about 1 meter wide in prairie.

## ARECIDAE

### ARACEAE

*Arisaema triphyllum* (L.) Schott, Jack-in-the-pulpit—*Kron 736 (AUB, MICH, MSC), north-facing slope of bowl.*

*Symplocarpus foetidus* (L.) Nutt., Skunk-cabbage—*Kron 978* (AUB, MICH, MSC), tamarack swamp.

### LEMNACEAE

*Lemna minor* L., Duckweed—*Kron 884* (MICH), in slowly moving water in stream running through the prairie.

## COMMELINIDAE

### COMMELINACEAE

*Tradescantia ohiensis* Raf., Spiderwort—*Kron 615* (MICH, MSC), prairie.

### JUNCACEAE

*Juncus canadensis* LaHarpe, Rush—*Kron 657* (AUB, MSC), prairie.
*J. dudleyi* Wieg., Rush—*Kron 646, 823* (both at AUB, MICH, MSC), prairie.
*J. greeneii* Oakes & Tuckerman, Rush—*Kron 658* (AUB, MSC), prairie.
*J. tenuis* Willd., Rush—*Kron 804* (AUB, MSC), prairie.
*Luzula acuminata* Raf., Wood rush—*Kron 742* (AUB, MSC), floor of bowl.

### CYPERACEAE

*Carex hirtifolia* Mackenzie, Sedge—*Kron 744* (AUB, MSC), north slope, steep, sandy.
*C. hystericina* Willd., Sedge—*Kron 662* (AUB, MICH, MSC), *827* (AUB, MSC), prairie
*C. laevivaginata* (Kük.) Mackenzie, Sedge—*Kron 819* (AUB, MSC), prairie.
*C. plantaginea* Lam., Sedge—*Kron 743* (AUB, MICH, MSC), floor of bowl.
*C. sterilis* Willd., Sedge—*Kron 623* (AUB, MSC), prairie.
*C. stricta* Lam., Sedge—*Kron 610* (AUB, MICH, MSC), *775, 965* (both at AUB, MSC), prairie.
*C. suberecta* (Olney) Britton, Sedge—*Kron 624* (AUB, MICH, MSC), prairie.
*C. tetanica* Schk., Sedge—*Kron 773* (AUB, MSC), southeast portion of prairie.
*Eleocharis intermedia* (Muhlenb.) Schultes, Spike-rush—*Kron 772* (AUB, MSC), southeast portion of prairie.
*Scirpus atrovirens* Willd., Bulrush—*Kron 825* (AUB, MICH, MSC), wet prairie.

### POACEAE

*Agrostis gigantea* Roth, Redtop—*Kron 826* (AUB, MICH, MSC), prairie.
*A. perennans* (Walter) Tuckerman, Upland bentgrass—*Kron 897* (AUB, MICH, MSC), prairie.
*Andropogon gerardii* Vitman, Big bluestem—*Kron 685* (AUB, MICH, MSC), prairie.
*Brachyelytrum erectum* (Roth) Beauv.,—*Kron 839* (AUB, MICH, MSC), eastern end of bowl, wooded slope.
*Bromus ciliatus* L., Fringed brome—*Kron 629* (AUB, MICH, MSC), prairie.
*B. latiglumis* (Shear) A. Hitchc.—*Kron 874, 904* (both at AUB, MICH, MSC), prairie.
*B. pubescens* Muhlenb., Canada brome—*Kron 831* (AUB, MICH, MSC), *901* (AUB, MSC), prairie.
*Calamagrostis canadensis* (Michaux) Beauv., Blue-joint—*Kron 609* (AUB, MSC), *647* (AUB, MSC), prairie.
*Cinna arundinacea* L., Wood reedgrass—*Kron 855* (MICH, MSC), along path through bowl.
*Elymus canadensis* L., Wild-rye—*Kron 929* (AUB, MICH, MSC), prairie.
*E. villosus* Willd., Wild-rye—*Kron 796* (AUB, MICH, MSC), *871* (MICH), thickets between prairie and bowl.
*E. virginicus* L., Wild-rye—*Kron 877* (AUB, MSC), *906* (AUB, MICH, MSC), eastern end of bowl.
*Festuca obtusa* Biehler, Nodding fescue—*Kron 802* (AUB, MSC), open area along edge of the floor of the bowl.
*Glyceria striata* (Lam.) A. Hitchc., Fowl manna grass—*Kron 628* (AUB, MICH, MSC), *821, 876* (both at AUB, MSC), prairie.
*Hystrix patula* Moench, Bottlebrush grass—*Kron 810* (AUB, MICH, MSC), south end of bowl, wooded slope.
*Leersia virginica* Willd., White grass—*Kron 840* (MICH, MSC), eastern end of bowl, wooded.
*Muhlenbergia glomerata* (Willd.) Trin., Marsh wild-timothy—*Kron 856* (AUB, MICH, MSC), prairie.

*M. mexicana* (L.) Trin., "Muhly"—*Kron 928, 930* (both at AUB, MICH, MSC), prairie.

*M. schreberi* J. Gmelin, Nimblewill—*Kron 889* (AUB, MICH, MSC), in sandy path through bowl.

*M. tenuiflora* (Willd.) BSP., "Muhly"—*Kron 866* (AUB, MICH, MSC), north-facing slope of bowl.

*Panicum clandestinum* L., Panic grass—*Kron 631* (AUB, MICH, MSC), along Love Creek, woods.

*P. dichotomum* L., Panic grass—*Kron 867, 886* (both at AUB, MICH, MSC), along path through bowl.

*P. implicatum* Britton, Panic grass—*Kron 792* (AUB, MICH, MSC), eastern end of bowl, rich wooded slope.

*P. virgatum* L., Panic grass—*Kron pers. obs.*, prairie.

*Phleum pratense* L., Timothy—*Kron 798* (AUB, MICH, MSC), eastern end of bowl.

*Phragmites australis* (Cav.) Steudel, Reed—*Kron 863* (AUB, MICH, MSC), prairie.

*Poa alsodes* A. Gray, Bluegrass—*Kron 766* (AUB, MICH, MSC), floor of bowl.

*P. pratensis* L., Kentucky bluegrass—*Kron 611* (AUB, MSC), prairie, introduced from Europe.

*Sorghastrum nutans* (L.) Nash, Indian grass—*Kron 695* (AUB, MICH, MSC), prairie.

*Spartina pectinata* Link, Cordgrass—*Kron 672* (AUB, MICH, MSC), prairie, south of main creek.

TYPHACEAE

*Typha angustifolia* L., Narrow-leaved cat-tail—*Kron 625* (AUB, MICH, MSC), wetter places in prairie.

## LILIIDAE

LILIACEAE

*Allium cernuum* Roth, Nodding wild onion—*Kron 643, 699* (both at AUB, MICH, MSC), petals white to pink, prairie.

*A. tricoccum* Aiton, Wild leek—*Kron 829* (AUB, MICH, MSC), wooded slope between tamarack swamp and bowl.

*Asparagus officinalis* L., Garden asparagus—*Kron 612* (MICH), one seen in prairie, European.

*Erythronium americanum* Ker Gawler, Trout-lily—*Kron 732* (AUB, MICH, MSC), south side of bowl steep slopes, loamy sand.

*Hypoxis hirsuta* (L.) Cov., Star-grass—*Kron 594* (AUB, MICH, MSC), prairie.

*Lilium michiganense* Farw., Michigan lily—*Kron 660* (AUB, MICH, MSC), prairie.

*Polygonatum pubescens* (Willd.) Pursh, Solomon-seal—*Kron 758* (AUB, MICH, MSC), slope of bowl, east end.

*Smilacina racemosa* (L.) Desf., False Spikenard—*Kron 763* (AUB, MICH, MSC), common on slopes of bowl.

*S. stellata* (L.) Desf., False Solomon-seal—*Kron 613, 780* (both at AUB, MICH, MSC), prairie.

*Trillium grandiflorum* (Michaux) Salisb., Common trillium—*Kron 716, 963* (both at AUB, MICH, MSC), thicket between prairie and bowl.

*T. recurvatum* Beck, Wake-robin—*Kron 721* (AUB, MICH, MSC), throughout tamarack swamp, thicket and floor of bowl. Threatened in Michigan.

*Uvularia grandiflora* Smith, Bellwort—*Kron 725* (AUB, MICH, MSC), rich woods at base of moraine, loamy soil.

*Zigadenus glaucus* (Nutt.) Nutt., White camas—*Kron 692* (AUB, MICH, MSC), prairie.

IRIDACEAE

*Iris virginica L.*, Southern blue flag—*Kron 598* (AUB, MICH, MSC), in wetter spots in prairie.

*Sisyrinchium angustifolium* Miller, Blue-eyed-grass—*Kron 794* (AUB, MICH, MSC), eastern end of bowl, wooded slopes.

SMILACACEAE

*Smilax lasioneura* Hook., Carrion-flower—*Kron 621* (AUB, MICH, MSC), *622* (MICH, MSC), twining vine on north side of main creek through prairie.

DIOSCOREACEAE

*Dioscorea villosa* L., Yam—*Kron 669, 818* (both at AUB, MICH, MSC), climbing vine, north of creek running through prairie.

ORCHIDACEAE

*Cypripedium calceolus* var. *pubescens* (Willd.) Correll, Yellow lady-slipper—*Kron 603* (MICH), *788* (AUB, MSC), tamarack swamp and south prairie.

*C. candidum* Willd., White lady-slipper—*Kron pers. obs.*, Threatened in Michigan.

*C. reginae* Walter, Showy lady-slipper—*Kron 602* (MICH, MSC), wet prairie.

*Habenaria lacera* (Michaux) Lodd., Ragged fringed orchid—*Kron 674* (MSC), prairie, one seen.

*H. psycodes* (L.) Sprengel, Purple fringed orchid—*Kron 862* (AUB, MICH, MSC), prairie between tamarack swamp and bowl.

*Liparis loeselii* (L.) Rich., Loesel's twayblade—*Kron 822* (MICH, MSC), wet prairie.

*Spiranthes cernua* (L.) Rich., Nodding ladies'-tresses—*Kron 704, 918* (both at AUB, MSC), prairie.

## ACKNOWLEDGMENTS

I gratefully acknowledge Drs. John H. Beaman, Ralph E. Taggart, and Stephen N. Stephenson for their critical comments and suggestions during the course of this study. I also would like to thank Dr. Walter S. Judd for his comments on the manuscript, and Dr. Edward G. Voss for his help in some of the determinations. A portion of this project was generously supported by the Hanes Fund Trustees.

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# VIOLA ×ECLIPES, A NEW HYBRID VIOLET

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Violet specialists and other taxonomists (Brainerd 1924; Cooperrider 1986; Grover 1939; Malte & Macoun 1915; Miller 1976; Russell 1965; Valentine 1981) have noted the occurrence of hybridization in the blue-and cream-flowered stemmed violets composing the rostrate violet group. Such hybrids have been found to date in the eastern North American representatives, among *Viola adunca* J. E. Smith, *V. conspersa* Reichenb., *V. rostrata* Pursh and *V. striata* Aiton. Two hybrids that have been reported from several states and Canadian provinces are *Viola ×maltena* House [*V. conspersa* × *rostrata*] and *V. ×brauniae* Grover ex Cooperrider [*V. rostrata* × *striata*].

Scoggan (1978) reported *V. conspersa* × *striata* from Lambton County, Ontario on the authority of a local flora by Gaiser & Moore (1966). Gaiser & Moore's report was based on a specimen (*L. O. Gaiser #2150T*, OAC) collected on 30 June 1959 near Thedford, Ontario. The plants, several specimens from a small clump, were noted on the label as having white flowers. The sheet was annotated "*Viola striata* Ait. × *V. conspersa* Reich.?" by Dr. N. H. Russell in 1960. A high quality photocopy of the sheet sent by Dr. J. M. Canne proved the specimens to represent the white-flowered form of *V. conspersa*, not *V. conspersa* × *striata*.

Examinations of herbarium specimens from AUB, CM, KE, MICH, MSC, NDG, OAC, PH, and WIS during other violet research have turned up 16 specimens of *V. conspersa* × *striata* from Indiana, Massachusetts, Michigan, Pennsylvania, and Ontario, Canada. Those that were originally identified below the genus level, were misidentified as *V. conspersa*.

Extensive field studies of Michigan violets have led to the discovery of many mixed-species populations of *V. conspersa* and *V. striata* and their interspecific hybrid. In most instances the parent species were locally common, and the hybrid grew scattered among the intermingling parent plants in good numbers.

This overlooked hybrid is known from many localities over the common range of *V. conspersa* and *V. striata* and will probably be discovered throughout this sympatric range. States where the hybrid has not yet been documented but is expected include Connecticut, Illinois, Kentucky, Maryland, New Hampshire, New Jersey, New York, Ohio, Rhode Island, West Virginia, and Wisconsin. The hybrid has proved to be just as frequent both in the field and in herbarium collections as *V. ×malteana* and *V. ×brauniae*. Like the latter hybrids, *V. conspersa* × *striata* is also highly

distinctive in morphology. Such a well-marked, widely occurring hybrid deserves a name, to wit:

**Viola ×eclipes** H. E. Ballard, *hybr. nov.* (Fig. 1)—TYPE: Michigan, St. Clair Co., SW-1/4 of NE-1/4 of Sec. 20 of Kenockee Twp., T7N, R15E, frequent near stream in floodplain, near *V. striata,* 14 May 1986, Ballard 86–003 (holotype: MICH!).

Hybrida e *Viola conspersa* Reichenb. et *V. striata* Aiton; sepalis longioris angustatis ciliolatis, stipulis fimbriatis, petalis caesiis distalis albis proximis, corollae nonocellato.

Cauline leaves irregularly crenulate, at least the upper often sparsely strigulose above near the margin and occasionally bearing small dense patches of clavate hairs; median leaves broadly ovate-cordate, obtuse to acute, 1–3 cm long. Cauline stipules lanceolate to lance-ovate, moderately to strongly fimbriate (especially the lower), 1–2 cm long. Petals pale blue distally with a broad white zone proximally, resulting in a watery blue corolla with a conspicuous white "eye"; lateral petals (frequently also the upper) densely bearded; spur 4–5 mm long, averaging 30% of the entire spur petal length (= blade plus spur). Lateral sepals barely to moderately ciliolate, lance-linear, with auricles elongating to 2 or more times their width. Habitat in swamp forests, low areas in mesic forests, and ecotones where rich alkaline floodplain grades into acidic swamp; commonly along paths, natural drainages, and other disturbed areas in such habitats where "intermediate" soil conditions are locally widely distributed.

The epithet *eclipes* refers to the hybrid's previously "eclipsed" nature, it being regularly mistaken for *V. conspersa.*

As with other hybrids in the rostrate violet group, *V. ×eclipes* possesses foliage that is clearly intermediate between that of its parents. Its median upper cauline leaves are ovate or nearly ovate-oblong in outline, being less reniform or broadly ovate than typical *V. conspersa* and with apices not so prolonged as in *V. striata.* Upper leaf surfaces are frequently endowed with scattered, subulate spicules characteristic of *V. striata,* but also occasionally possess small patches of dense, clavate hairs seen frequently in *V. conspersa.* Stipules are lance-ovate and quite fimbriate—broader than the linear-lanceolate, sparingly lacerate stipules of *V. conspersa* and expressing in part the broad, strongly fimbriate stipules of *V. striata.*

There is also intermediacy in its floral morphology. Petal orientation in *V. conspersa* is noticeably more horizontal, with petals less spreading than in *V. striata,* whose petals are open to support and receive landing hawkmoths. The flower of *V. ×eclipes* shows a more or less intermediate petal orientation, the petals more widely spreading and "flattened" than in *V. conspersa.*

However, corolla color pattern in the new hybrid shows a striking deviation from the pale blue concolorous corolla one would expect from a cross between cream-colored *V. striata* and light blue-violet *V. conspersa.* The flower of *V. ×eclipes* is watery, pale blue with a dramatic, large off-

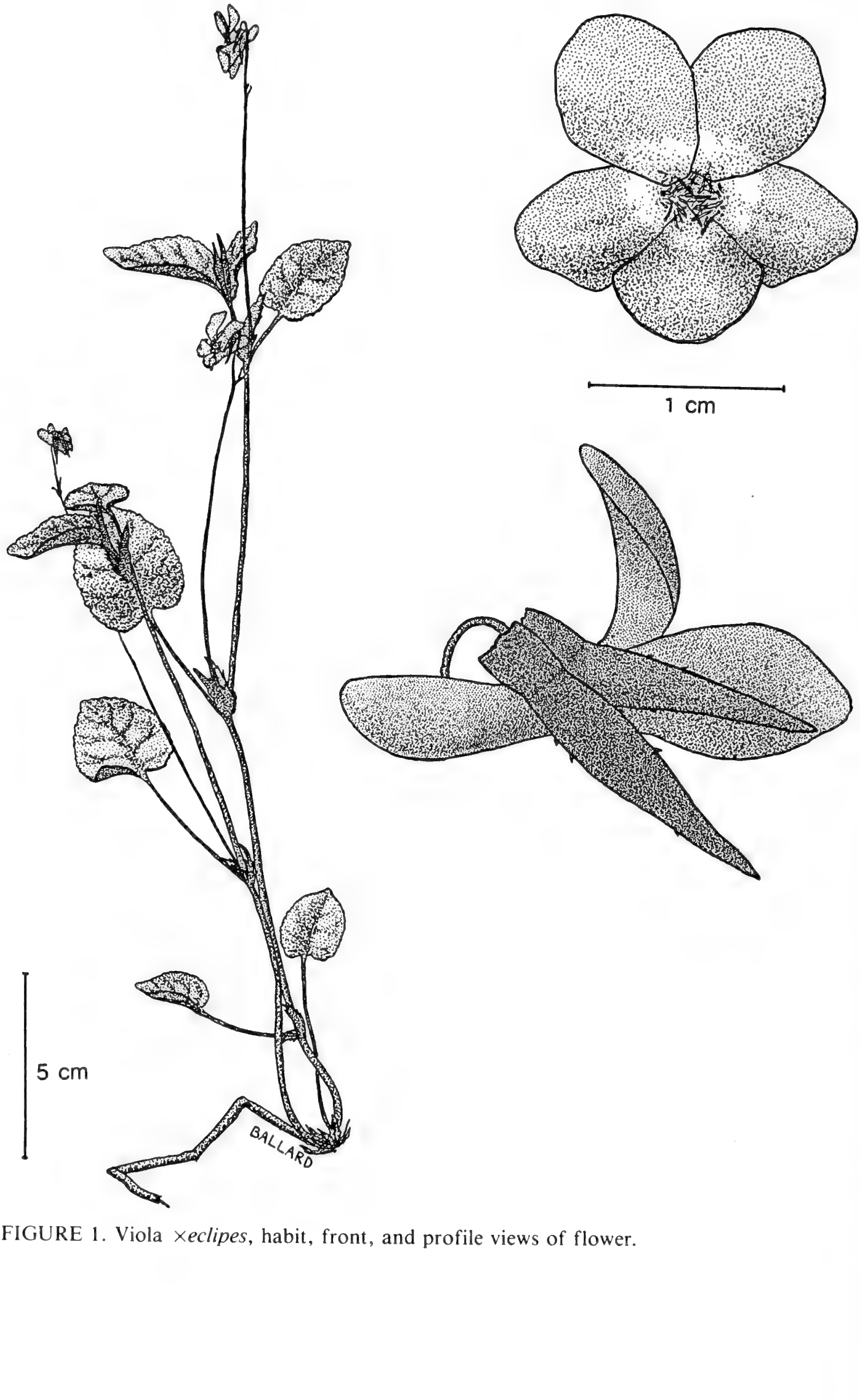


FIGURE 1. Viola ×*eclipes*, habit, front, and profile views of flower.

white “eye“. This unexpected corolla color pattern in *V. ×eclipes* might be explained, in the absence of hard data, as the combined expression of intermediate petal structure (which may expose some of the usually hidden, white interior of the throat) and differential pigmentation of the petals.

ACKNOWLEDGMENTS

I am grateful to the curatorial staff at AUB, CM, KE, MICH, MSC, NDG, OAC, PH, and WIS for assistance in locating specimens during my visits and for sending photocopies of specimens.

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## REVIEW

ENCYCLOPAEDIA OF FERNS. By David L. Jones. Timber Press, 9999 S. W. Wilshire, Portland, OR 97225. 1987, reprinted 1988. xvii + 433 pp. $55.95, hardbound.

The title *Encyclopaedia of Ferns* is a flagrant deception since this volume is merely an introductory account attempting to cover about the same ground as Barbara Joe Hoshizaki's Fern Growers Manual (1975), albeit with an emphasis on the author's home country, Australia. The main value of the book is in the excellently printed illustrations, 250 in color, many of which are quite beautiful; I only noticed one misidentification, as *Polypodium pectinatum,* on p. 249.

But despite the very handsome appearance of the book, the text is not authoritative and is often padded with useless verbiage. The classification scheme presented on pp. 56–57 (which strangely groups *Thelypteris* with *Dennstaedtia*) is neither followed elsewhere in the book, where other family names unmentioned in the classification are used, such as Aspidiaceae, nor in the unordered groupings in part six, "Ferns to Grow," where among other anomalies, *Quercifilix*, a tropical relative of *Tectaria,* is placed as a hardy relative of *Cheilanthes.*

I counted 17 places where the term "synganium" appears in error for synangium, among other gaffs in terminology. My greatest peeve in that regard, however, is the misuse of the word 'spore' as a collective noun, as in "Aspleniums can be readily raised from fresh spore," but this was not done consistently, sometimes switching back and forth between spore and spores, even in the same paragraph.

The index is incomplete. Information seems to have been compiled from various unspecified sources, and is often inaccurate. For example, even though Copeland's *Fern Flora of the Philippines* is included in the bibliography, the listed distribution omits the Philippines for even some species that were first discovered in and described from that country, such as *Asplenium excisum* (p. 228) and *Nephrolepis falcata* (p. 308). I'm sorry to say I cannot recommend this book; the best general reference for the serious fern-loving gardener remains Hoshizaki's volume mentioned above, which is still available.

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# INDEX TO VOLUMES 26, 27, AND 28

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This index follows the general format and philosophy of previous indexes. Scientific names are cited for *every* occurrence on every page, including figure legends. Common names are not indexed. Names above the level of genus are not indexed. A full citation of authors and title is only given for the first author; citation for all other authors is given by a reference to the first author. Misspellings [very rare] are corrected, wherever they were detected; this is not done from a motive of calling attention to another's mistakes, but on the assumption that no one will think to look up a word via a misspelling.

NEW NAMES PUBLISHED IN VOLUMES 26-28.

## ANNOUNCEMENT: RARE LICHENS PROJECT

A project to determine the conservation status of the lichens of North America north of Mexico, and Hawaii was recently begun by Mason E. Hale, Jr., and Sherry K. Pittam of the Department of Botany, Smithsonian Institution, in cooperation with The Nature Conservancy.

The project's goal is to generate a list of rare or endangered lichens with the necessary information to seek protection for species as appropriate, and to provide this information to the Conservancy and to other conservation organizations and land-management agencies. When possible, potential threats to individual species, as well as geographic distribution and abundance, will be noted. Taxonomy will follow Egan's checklist (as revised).

Those interested are invited to provide names of potentially rare or endangered species of lichens, with available supporting information. Please send to Sherry K. Pittam, Rare Lichens Project, Smithsonian Institution, Botany/NHB 166, Washington, DC 20560. Telephone (202)357-2545.

## ANNOUNCEMENT: ECOLOGICAL RESTORATION CONFERENCE

The Society for Ecological Restoration announces its second annual conference, to be held in Chicago, IL at the Sheraton International Hotel at O'Hare Airport, April 29–May 3, 1990.

The program will include several special sessions to explore the state of the art as it applies to key environmental issues as well as a full program of contributed papers and posters, special lectures, workshops, field trips, and other special events designed to facilitate communications among restorationists and with decision makers and the general public.

The topics of the special sessions are: prairie restoration, restoration and global climate change, setting standards for monitoring restoration projects, restoration and recovery of endangered species, and restoration philosophy. Several field trips are planned, including visits to the Fermi National Laboratory prairie restoration, wetlands restoration along the Des Plaines River, the Indiana Dunes National Lakeshore, urban prairies in Chicago, and the University of Wisconsin Arboretum.

Additional information about the conference can be obtained from the Society office:

Society of Ecological Restoration and Management
The University of Wisconsin Arboretum
1207 Seminole Highway
Madison, Wisconsin 53711

The May issue (Vol. 28, no. 3) was mailed September 15, 1989

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On the cover: *Showy black-eyed Susan (Rudbeckia sullivantii) at Indian Bowl wet prairie, Berrien County, Michigan.*
*Photographed by Kathleen Kron, September 1981.*